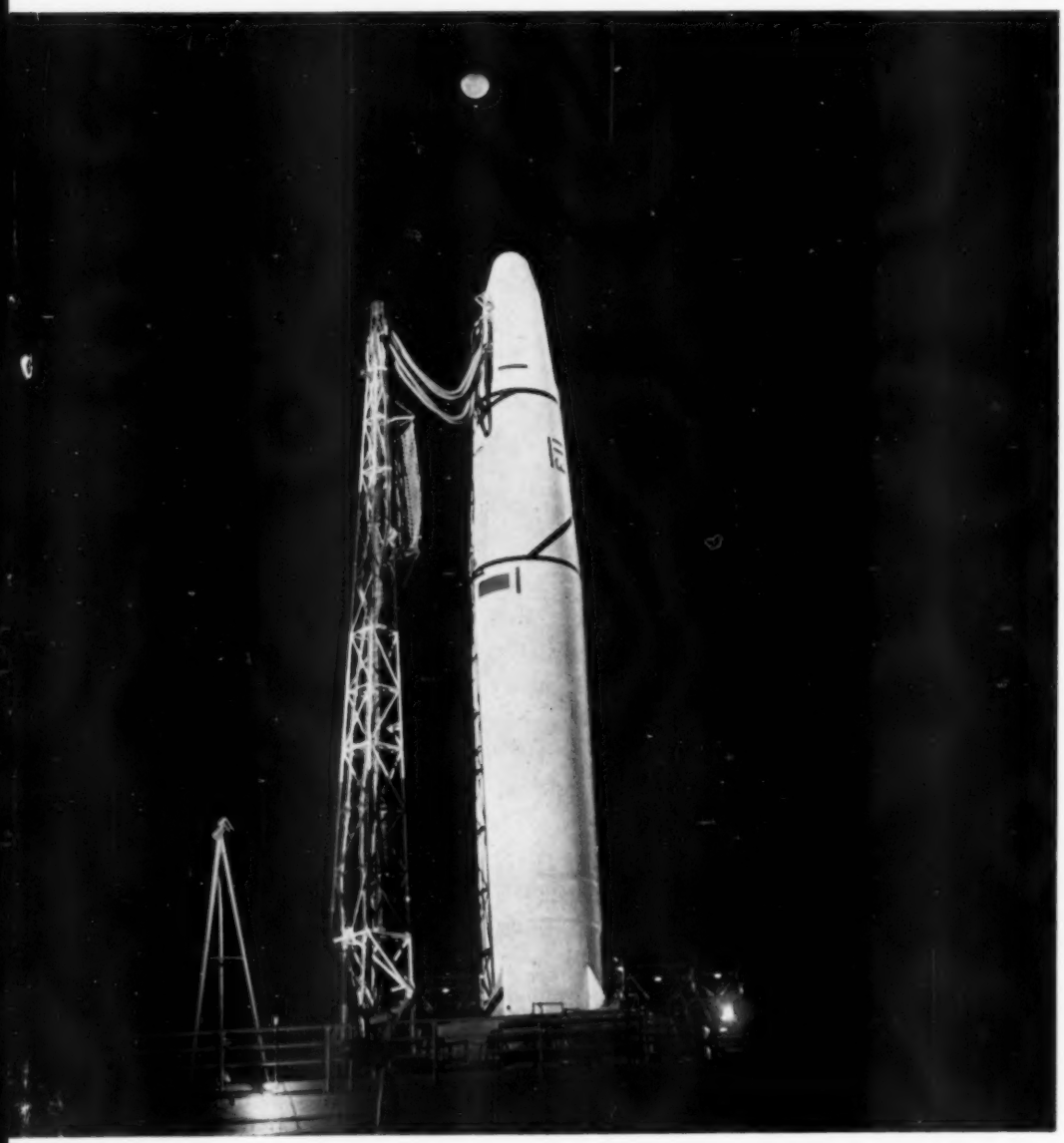
ORDNANCE

LAND · SEA · AIR · SPACE



Thor—Reaching for the Moon

SEPTEMBER-OCTOBER 1958

SPECIAL PICTORIAL REPORT ON OUR SEABORNE ORDNANCE . . . . PAGE 231

Radical new concept in handling bearings speeds shipping

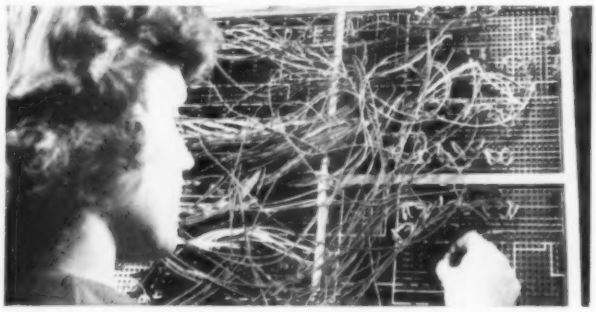
Helps you 6 ways when you buy Timken® bearings

To give you faster, better service when you buy Timken® tapered roller bearings, the Timken Company has developed a revolutionary new concept in warehousing, order processing and shipping. All the elements of the system converge at our huge new $5,000,000 Shipping Center in Bucyrus, Ohio, that enables us to get your bearings out faster and more dependably than ever before. It helps you in six important ways.

1. Reduces time required to process your bearing order. The new system, which uses the electronic computer, enables us to give you an acknowledgment and shipping date on most orders within 24 hours. **2. Cuts shipment and invoice preparation time.** Makes things easier for your purchasing department.

3. Your order comes completely from one shipping point. Single source handling further speeds your bearing shipment. **4. Your orders having the same shipping date are consolidated.** Increases handling efficiency at your plant when you receive your Timken bearings.

5. The new system helps assure delivery when promised, because it controls our production to meet your needs. **6. It gives you a practically** unlimited source of supply for tapered roller bearings, from our normal warehouse inventory of over 12 million bearing cones and cups.



And the IBM Computer (grid of which is shown above) is the system's heart. It integrates the Shipping Center with all our production facilities—controls the system which speeds order processing and keeps our production in line with your needs. This totally new concept in customer service is one more reason why you get your No. 1 bearing value when you buy Timken bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

BETTER-ness rolls on

TIMKEN®

tapered roller bearings

ORDNANCE

LAND · SEA · AIR · SPACE

Thirty-nine Years of Leadership in American Armament

VOL. XLIII | SEPTEMBER-OCTOBER 1958 | NO. 230

The Cover.—*The Air Force's 62-foot, 100,000-pound Thor, with a normal range of 1,500 to 2,000 miles, is scheduled to boost three lunar probe rockets and launch a reconnaissance satellite. The Thor-Able combination is also testing reëntry vehicles.*

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more
Alcoa Imagineering
for defense...

HOW TO STEER MISSILES AT MACH 4

AT MACH 4, THINGS GET HOT. NOSE CONES FOR MISSILES TRAVELING AT SUCH SPEEDS MUST BE THICK-SKINNED, DEFY INFERNO HEATS. THEY MUST BE THIN-SKINNED, TOO, ABLE TO RECEIVE AND SEND GUIDING ELECTRONIC IMPULSES WITHOUT INTERFERENCE. THE TASK CALLS FOR A JEKYLL AND HYDE CERAMIC. PARADOXICALLY, THAT RARE COMBINATION OCCURS IN THE MOST COMMON OF EARTHS . . . ALUMINUM OXIDE. NOSE CONES OF HIGH ALUMINA COMPOSITION WILL SEE MISSILES THROUGH THICK AND THIN. PURE ALCOA® ALUMINA, HIGHLY RESISTANT TO THERMAL, ELECTRICAL AND MECHANICAL SHOCK, IS THE BUTTRESSING INGREDIENT MANY BASIC INDUSTRIES USE IN ELECTRONIC REFRACTORIES AND MECHANICAL CERAMICS. ALCOA DOES NOT MAKE RADOMES, BUT IT DOES SUPPLY ALUMINAS AND TECHNICAL ASSISTANCE TO CERAMIC MANUFACTURERS WHO DO. FOR A LIST OF CERAMIC RADOME MANUFACTURERS, CONTACT ALUMINUM COMPANY OF AMERICA, 849-G ALCOA BUILDING, PITTSBURGH 19, PENNA.

ALCOA ALUMINUM

Your Guide to the Best in Aluminum Value

This CAT No. 933 Traxcavator mixes and feeds cinders for 1,000 blocks an hour

When crushed volcanic cinders are stored at Orco Block Co., Stanton, Calif., the fine particles sift to the bottom of the pile. To mix before use and feed the hoppers, the company depends on a Caterpillar No. 933 Traxcavator.

"It takes the flotation of a crawler tractor to maneuver on a cinder pile," testify P. Muth and A. Johnson, Orco Block Co. owners. "The No. 933 has the power we need for 1,000-block-an-hour production—and it gives very satisfactory service."

The No. 933 is one of the most versatile machines for material handling. Its features include 40-degree tilt-back of the bucket at ground level to assure full loads at every pass; one-hand bucket and lift controls for quick, easy operation, and balanced, unit design that means faster cycle time.

There are three Traxcavators in the Caterpillar line—the No. 933 (50 HP, 1 cu. yd. bucket capacity), No. 955 (70 HP, $1\frac{1}{2}$ cu. yd.), and No. 977 (100 HP, $2\frac{1}{4}$ cu. yd.). The new Side Dump Bucket is available now on the No. 955 and No. 933.

Your nearby Caterpillar Dealer will give you the *facts* and a demonstration on *your* job. And after you buy, you can depend on him for good, prompt service and parts you can trust.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

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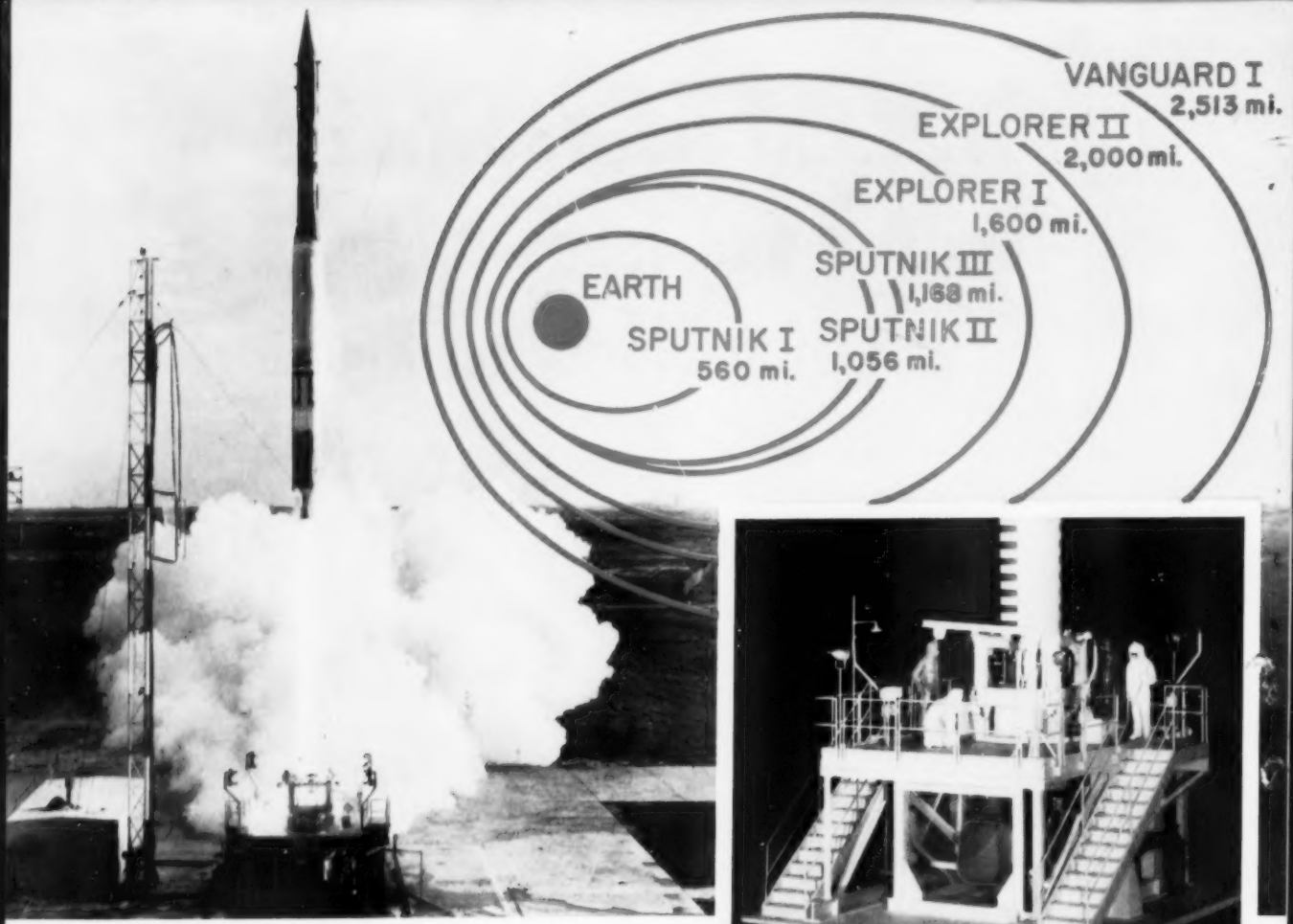
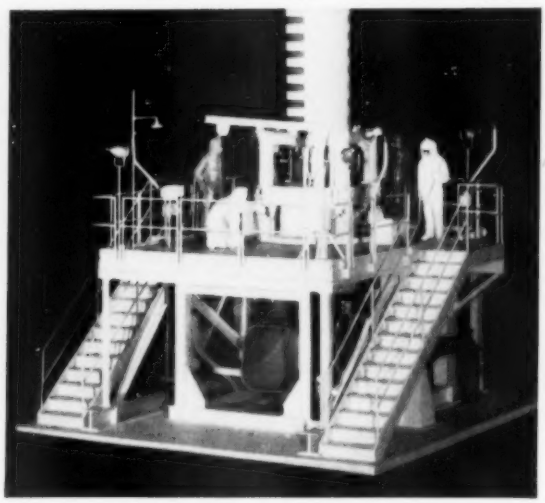
WANTED—
THE HARD WORK



Vanguard I being launched into orbit from Loewy-Hydropress flight-firing installation at Cape Canaveral, Fla.



Scale model of Loewy launching platform and rocket stand.

Loewy launching installation helps boost American moon to highest altitude of all satellites

On March 17, the Navy's Vanguard rocket, built by The Martin Company, soared from its Loewy-Hydropress launching installation into the blue and into orbit at the greatest altitude of all satellites—2500 miles from the earth at apogee.

When Vanguard misfired, on December 6, 1957, in this country's first attempt to put up a satellite, the conflagration could have completely destroyed the launching facilities. But Loewy had designed and built them so well that damage was extremely limited. The fire-fighting system released a torrent of water fog to combat the intense heat of the burning rocket fuels. Within an hour of the mishap, Loewy engineers were assessing the damage and lining up repair crews. Within a week, the static and flight-firing facility was repaired, and Vanguard's second stage was erect and under test. One more week and the first stage stand and weight recording system were completely repaired and operational.

The launching pad is 15 x 20 ft. in area. On it is erected a 6-ft. cubical test and flight-firing stand. Equipped with mechanical, hydraulic and electronic instrumentation, a unique flame-deflecting system and fail-safe devices, this installation has the function of static testing and flight firing. It also weighs the rocket and its fuel and measures the thrust of the first and second stage engines.

Because of its experience in missile launching and handling systems, Loewy-Hydropress is the coordinating agency for the combined rocketry facilities of all Baldwin-Lima-Hamilton divisions. Consult us about any problems that may confront you in research, development, design, construction or manufacturing for the structural, hydraulic, electronic and thrust measurement elements. Write to Dept. H-9

Loewy-Hydropress Division

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CONTROLLED FRAGMENTATION

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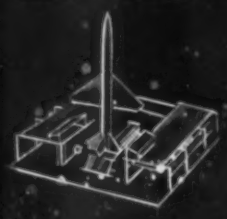
STRUCTURES

PROPULSION

CONTROL SYSTEMS



GROUND-SUPPORT EQUIPMENT

AT THE TAPCO GROUP...

Fully-integrated facilities for design, development, and production of components, assemblies, sub-systems, and systems...

TAPCO GROUP

consisting of Accessories, Jet, Electronics, Pneumatics and West Coast Divisions

Thompson Products, Inc. CLEVELAND 17, OHIO

...GET DETAILS ON NEXT PAGE

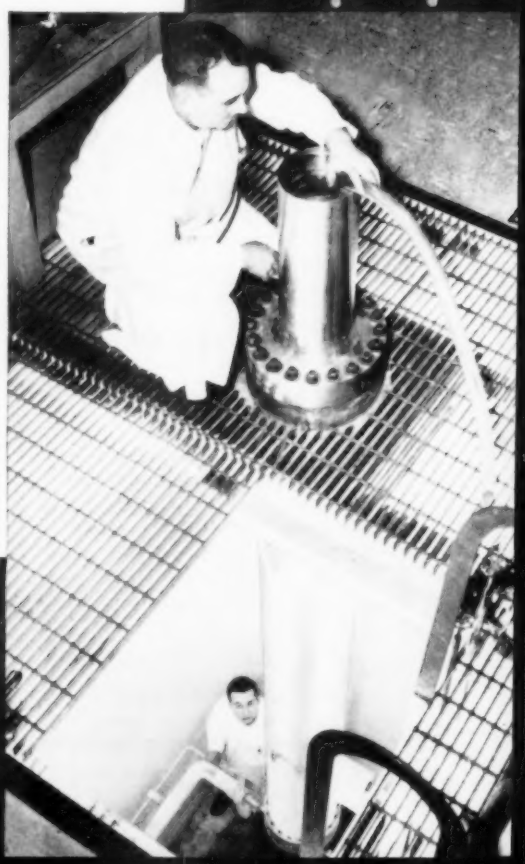
TAPCO INTEGRATED FACILITIES

provide components and assemblies for propulsion systems and complete auxiliary and accessory power sub-systems

Over 50 years of experience in developing metals and designing components for power plants gives the Tapco Group a vast experience in research, development and manufacturing of assemblies and components for propulsion and power systems and sub-systems.

Now, Tapco's capabilities have been broadened to include most phases of nuclear-power plants and accessories. Research is under way on the special metallurgical problems associated with radiation effect.

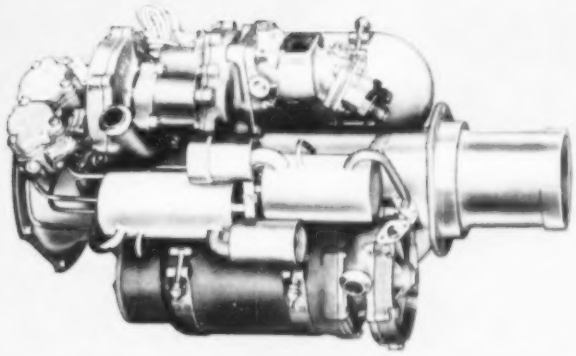
Fuels for all types of engines and power plants are collateral research projects at Tapco, where complete facilities for research and evaluation on solid-state, liquid and nuclear fuels are in existence.



Function testing of nuclear reactor control rod drive mechanisms ▶ in a simulated vessel head; part of Tapco's continuing research project on nuclear reactor components and control systems.

◀ Special problems of forming, heat-treating, and resistance welding were solved at Tapco in producing this large weldment for jet engines.

Self-contained solid-propellant auxiliary power unit designed and built at Tapco to produce electric and hydraulic power. ▼



At left: Combination main and afterburner engine-driven fuel pump now providing thousands of hours of trouble-free service in production fighter aircraft.

At right: Rocket engine turbo pump now in production at Tapco for use in several of America's leading missiles.

TAPCO GROUP

consisting of Accessories, Jet, Electronics, Pneumatics and West Coast Divisions

OTHER INTEGRATED SERVICES FROM TAPCO INCLUDE DESIGN, DEVELOPMENT OR PRODUCTION IN THE FIELDS OF STRUCTURES, ELECTRONICS, METALLURGY AND NUCLEAR POWER.

Thompson Products, Inc. CLEVELAND 17, OHIO

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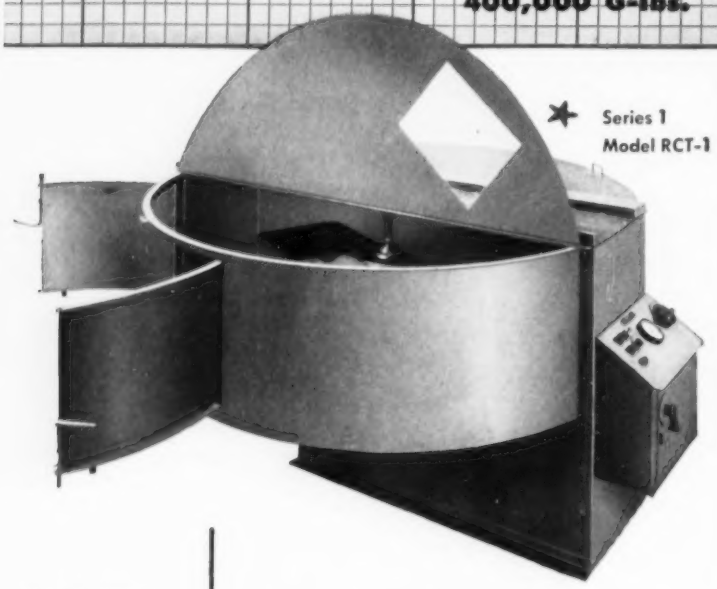
TEST LOADINGS OF MISSILE COMPONENTS and ASSEMBLIES

...up to: 150 G
8,000 lbs.
400,000 G-lbs.

other RUCKER PRECISION EQUIPMENT



★ Series 1
Model RCT-1

FULL RANGE of 8 MODELS AVAILABLE

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G-rating: 1 to 150
Test radius: 18" to 46"
Specimen: 30-100 lbs.

SERIES 10
G-rating: 1 to 150
Test radius: 96" to 240"
Specimen: 300-600 lbs.

SERIES 20
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Test radius: 264" to 420"
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RUCKER *Centrifuge*
ACCELERATION TEST MACHINES

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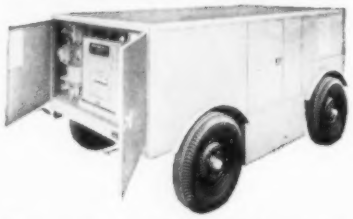
• **HI-PRESSURE GAS BOOSTERS**

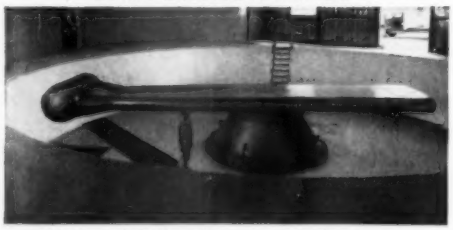


Stationary or portable high pressure gas boosters for compressing helium or nitrogen up to 6000-10,000 p.s.i. for missile development and production testing or flight line checkout.

• **TEST BENCHES**

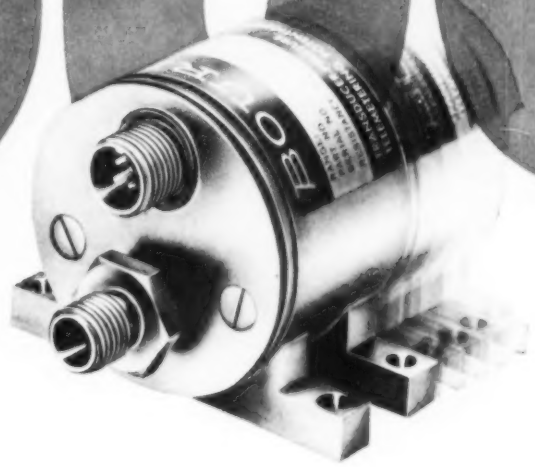
Standard or custom designed stationary or portable test benches for precision testing of all types of hydraulic or pneumatic components and systems.

★ **Series 20 Model RCT-21**



View of 22' radius arm and powerhead installed in test pit. This large Series 20 unit is designed for testing 4,000 lb. specimen at 100 G-rating.

35G



NEW PRESSURE TRANSDUCER: LOW VIBRATION ERROR AT 2000 CPS, 35G

Combine this with 0.17% resolution and you have truly remarkable performance. What's more, this new Model 717 Absolute Pressure Transducer is *in volume production* in ranges up to 4,000 psia.

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New concepts in basic design are being combined with high performance in new Bourns accelerometers, pressure transducers, linear motion potentiometers, and other electro-mechanical devices. When your requirements need the experience of a leader—look to BOURNS.

Write for detailed technical information on Model 717

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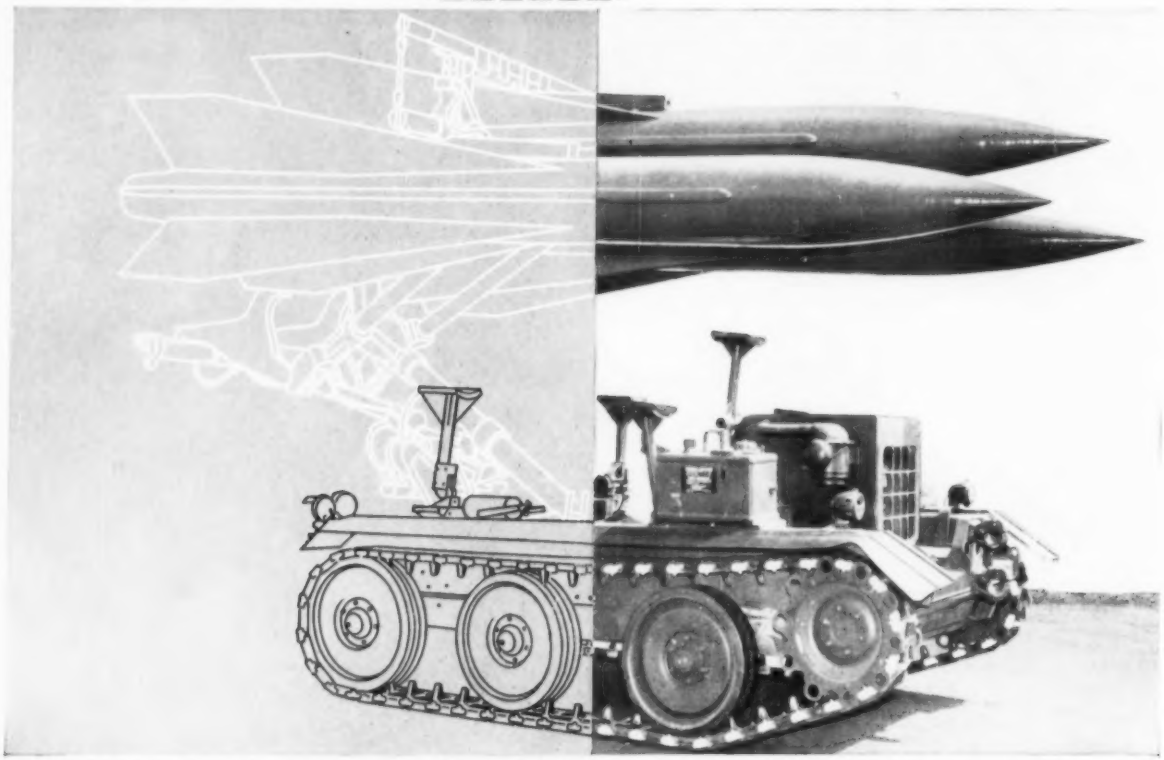

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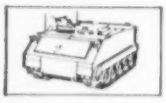
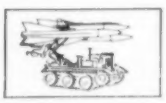
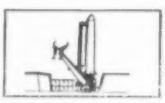


Multi-Purpose Vehicles

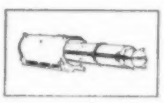
Prime Movers



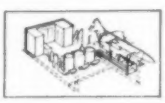
Transporter-Loaders



Launcher-Erectors & Power Units



Shipping & Storage Containers



Propellant Handling Systems

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

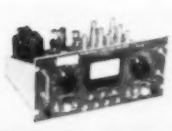
Ordnance Division

Missile Equipment Section 6-B

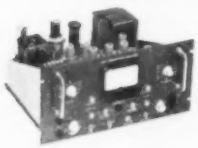
1105 COLEMAN AVENUE, SAN JOSE, CALIF.

1953
MODEL 2541A

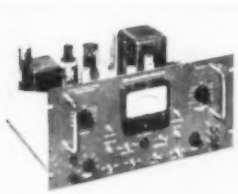
1954
MODEL 2541B



1955
MODEL 2541C



1956
MODEL 2541D



1957
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1958
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*MEETS REQUIREMENTS
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Military Specifications
MIL-E-4158A (USAF)

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The Team behind Tall Tom

The Hoffman TEAM approach (Total Engineering and Administrative Management) is a new concept in electronic systems management. Under the leadership of Hoffman as prime contractor, the TEAM is concentrating the maximum engineering capabilities of eight selected firms on development of the Air Force's highly sophisticated TALL TOM (AN/ALD-3) Electronic Reconnaissance System. The TALL TOM TEAM gives promise that the complete system will be delivered at a substantial saving in time and money.

By utilizing with optimum efficiency and economy the specialized talents of any number of large and small organizations, the Hoffman TEAM concept is directly applicable to research, development and production of other complex electronic systems. Inquiries are invited regarding the application of this unique Hoffman TEAM approach to your systems problems.

Hoffman Electronics CORPORATION

HOFFMAN LABORATORIES DIVISION · 3740 South Grand Avenue, Los Angeles 7, California

Weapons Systems · Radar · Communications · Electronic Countermeasures · Navigation

Semiconductor Applications · Missile Support Equipment · Electro-Mechanical Equipment

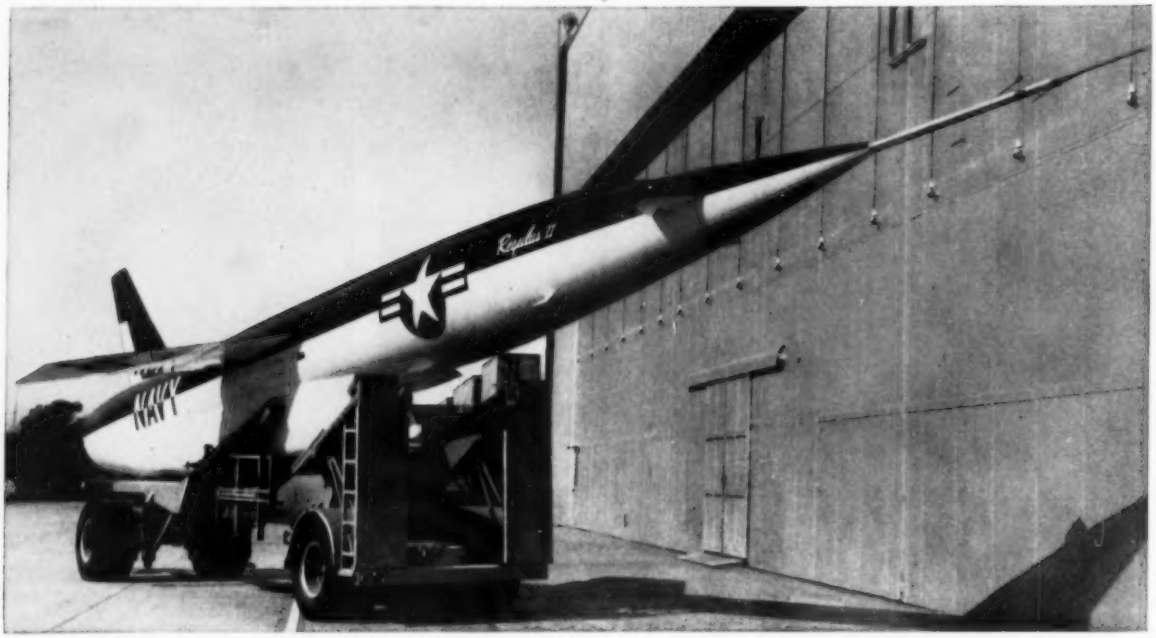
Significant developments at Hoffman have created positions for scientists and engineers of high calibre. Please address inquiries to Vice President, Engineering

BURROUGHS "VEST POCKET CREW" PACKS A TRIPLE WALLOP

AIRBORNE DIGITAL ELECTRONIC COMPUTER WILL "TAKE OVER" FOR PILOT, NAVIGATOR AND BOMBARDIER ON NAVY'S NEWEST JET BOMBERS. The crowded quarters of carrier-based aircraft leave little room for electronic "brains"—a scant few cubic feet in the case of the Navy's requirement for its AN/ASB-8 program: a package computer capable of target-approach pilotage, navigation and precision bombardment. And that's just what Burroughs, working closely with the Naval Ordnance Test Station, China Lake, is doing—cutting a roomful of equipment down to size. Burroughs Corporation, 6071 Second Avenue, Detroit 32, Michigan.

Burroughs Corporation

"NEW DIMENSIONS / in computation for military systems"



Chance Vought Regulus II guided missile launcher—designed and built by Fruehauf.

Fruehauf Ingenuity Illustrated In Many Ground Handling Units!

The range of Fruehauf design and manufacturing involves participation in the following major projects:

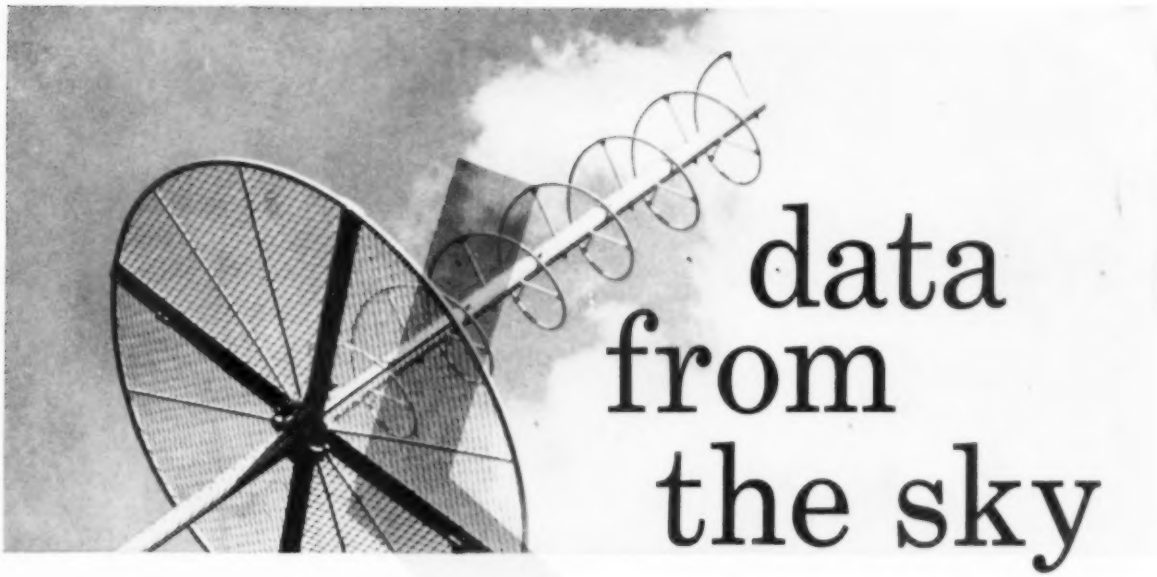
NIKE AJAX	BOMARC
NIKE HERCULES	ATLAS
GENIE	TITAN
REDSTONE	CORPORAL
BLUE GOOSE	HAWK
THOR	POLARIS
REGULUS I & II	SERGEANT
MATADOR	JUPITER

Consult Fruehauf for complete research, development, design, and construction facilities for any ground handling problem concerning missiles, guidance shelters, or weapons systems.

FRUEHAUF

MISSILE PRODUCTS DIVISION

10942 Harper Avenue, Detroit 32, Michigan
5137 South Boyle, Los Angeles 58, California



data from the sky

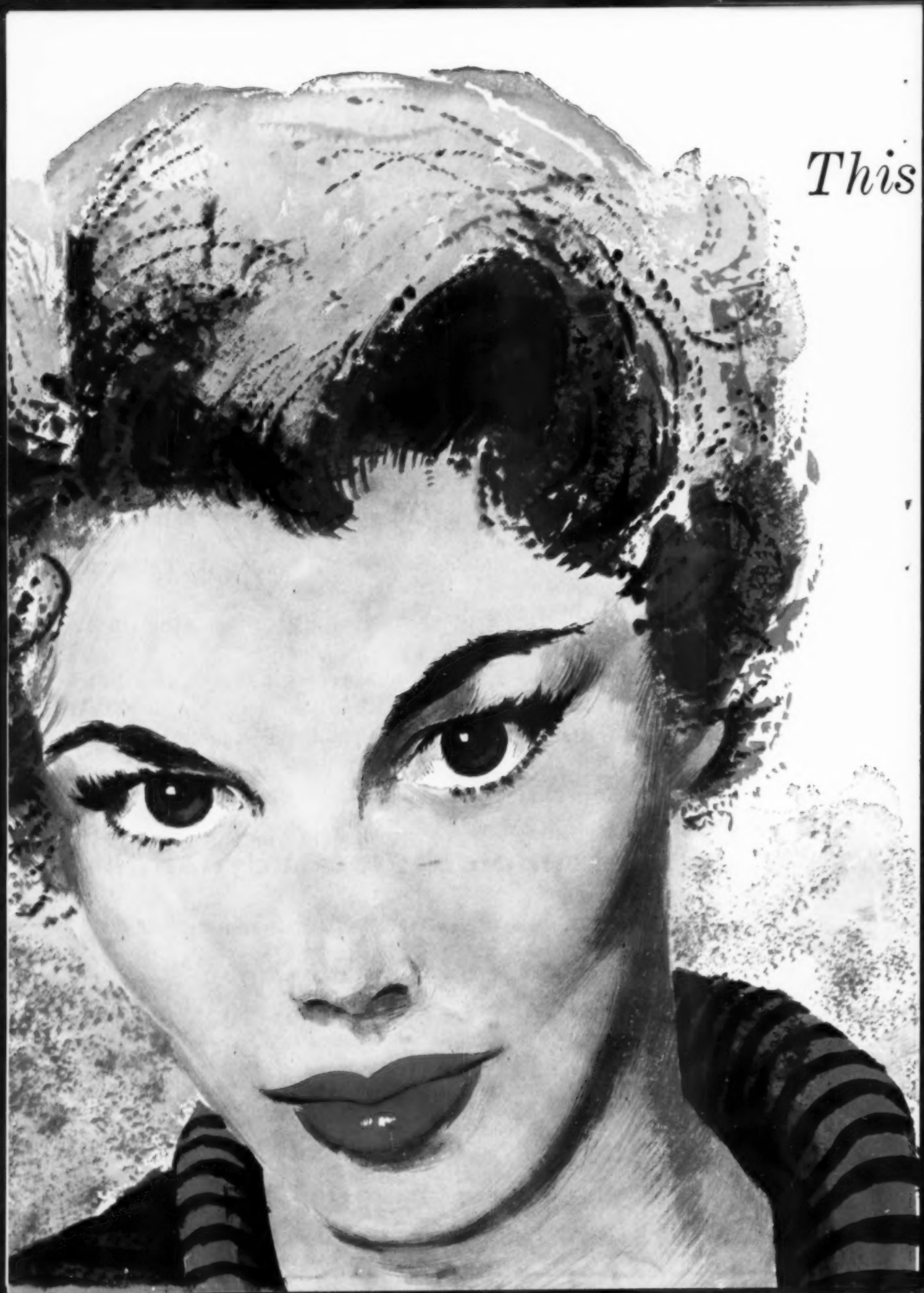
Significant data from airborne vehicles . . . missile and aircraft structures . . . power plants . . . complex weapons and control systems . . . are being gathered by Consolidated Systems designed to produce useful information in a minimum of flights or firings. These are systems of proven design, based on unmatched experience in recording, converting, and reproducing selected in-flight data. Read the complete story in BULLETIN CEC 3014-X4.

systems division **Consolidated Electrodynamics**

300 N. Sierra Madre Villa, Pasadena, California / Offices in Principal Cities Throughout the World

CEC

Telemetered and recorded data are made available in the form of analog or digital magnetic tapes, punched paper cards or tapes, visual displays, and direct-readout oscillograms.


This

is the Mrs. behind the

MISSILE

ON THESE TWO PAGES YOU WILL READ HOW SHE HAS SOLVED ONE OF THE GREATEST PROBLEMS IN THE DEVELOPMENT OF GUIDED MISSILES TODAY

. . . and where

AC

fits in this picture

IT TAKES a special kind of woman to be the wife of one of today's missile men.

It takes a woman who can live within shouting distance of Death Valley . . . or the New Mexican desert around Holloman Air Force Base and White Sands. It takes a woman who can pack up the kids at a moment's notice for a few months' stay at Cape Canaveral, Florida . . . or Point Mugu, California.

You'll find these women everywhere in our Army, Navy and Air Force. You'll find them as the wives of scientists, or married to engineers for some of the largest industrial concerns in the nation.

They know more about the problems of raising a family virtually alone than they do about the business of producing the missiles themselves.

This advertisement is a tribute to the courage of such women, and to the very real contribution they are making to the development of a guided missile arsenal for this nation's defense.

Where AC fits in this picture

AC has been a leader in the development of an inertial guidance system for use in many types of guided missiles. This system, which we call the AChiever, is now in ballistic missiles and air-breathing missiles developed for use by our armed forces. It has made headlines and proved itself in flight in such missiles as the Air Force's Thor and Matador . . . and in the Navy's Regulus II.

The AChiever has far broader application than most systems developed for a similar purpose. It can, for example, guide a missile far beyond the confines of earth. It could put a satellite into orbit . . . or take a rocket to the moon . . . and it is not subject to interference by any known natural or man-made force. And, AChiever is in volume production.

These remarkable accomplishments have been made possible in large part by the faith and understanding of the wives of the men at AC and their counterparts in the armed forces, in science and industry.

—If you are such a woman, and your husband has engineering or scientific training which could make a contribution to this program, and is not a member of the armed forces, ask him to write—or write yourself—to the personnel section of AC in Milwaukee.

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

From the best evidence available, Russia pours 25% of her gross national product into national security. The result: extremely potent weapons . . . and a lower standard of living.

Must "More Defense" Mean Rich Weapons . . . Poor Citizens?

Not for the U.S.: if we continue the effort to put defense on a businesslike basis. As General Electric sees it, we can achieve security with solvency.

Russia's Sputnik successes dramatically emphasize Soviet military progress . . . and the dilemma America faces because of that progress.

For the third time in 18 years, our free enterprise system is being tested against a slave-state system. While we cannot risk a "second best" defense establishment, neither can we increase defense spending to the point where we destroy our dynamic, expanding economy. And, certainly, we cannot adopt the very methods of dictatorship against which we are defending ourselves.

What then is the answer? One approach is to continue to aim for *more defense per dollar spent*—better aircraft, missiles, radar, engines—within the framework of reasonable budgets by . . .

- **ELIMINATING STOP-AND-GO DEFENSE PROGRAMS** . . . planning and budgeting well ahead so that the defense effort is stabilized.
- **PROVIDING PROPER INCENTIVES TO PERMIT INDUSTRY** to invest more private funds in defense and to make dynamic new technological contributions.

The problem is to put defense on the most businesslike basis.

Our military-industrial team is working hard to solve this problem. But its complete solution will be possible only if long-range defense is understood —and supported—by U.S. citizens. Survival is everybody's business. 6/5-1B

This public information message also appears in current issues of NEWSWEEK and FORTUNE.

GENERAL ELECTRIC

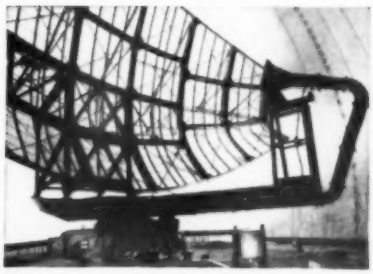
ROBERT PAXTON
President
General Electric Company

How can industry help to achieve more businesslike defense?

"We must step up our national productivity which has leveled off at the very time an increase is most needed. It has been estimated that, regardless of a recession, our level of productivity is as much as 20% below its present potential. With present facilities and work force—and the same number of working hours—we should be able to increase our gross national product more than $80 billion.

"Working for this goal means the elimination of needless waste and costly 'featherbedding'; greater cooperation between labor and management in introducing technological advances; and more purposeful, more efficient, and more imaginative work from everyone."

At General Electric, defense development is an operating business.



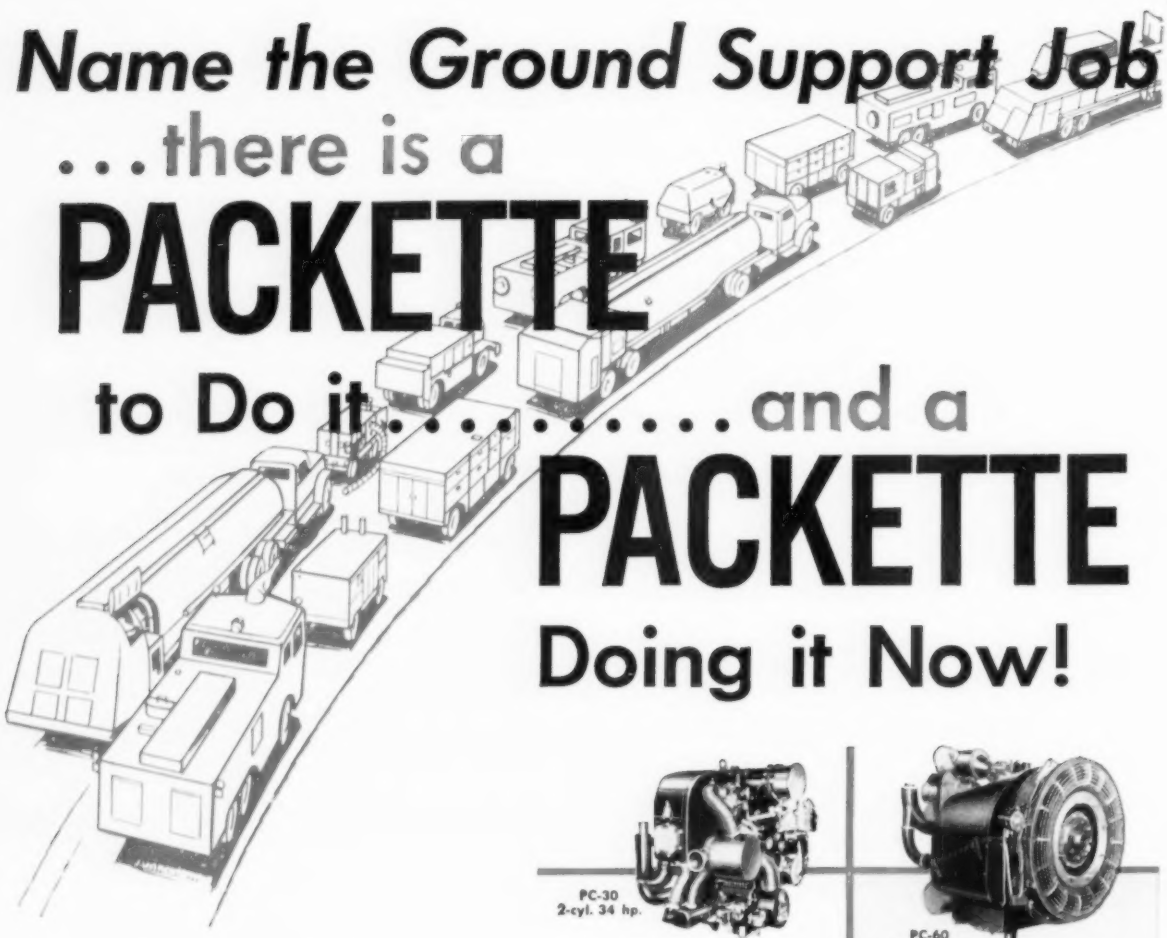
SURFACE-BASED ELECTRONIC SYSTEMS... including detection, location, control, missile guidance and detection . . . are developed and produced by the Heavy Military Electronics Equipment Department, Syracuse, N. Y.

NOSE CONES FOR ATLAS AND THOR missiles are being developed and tested by the Missile and Ordnance Systems Department, Philadelphia, Pa. Nose cone (above) is being packed in its carrier case.

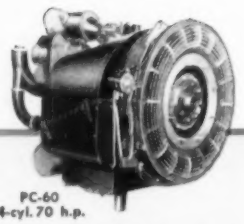
POWERFUL J79 TURBOJET ENGINE (above), product of the Aircraft Gas Turbine Division, Cincinnati, Ohio, recently powered the F-104 "Starfighter" to new world's speed and altitude records.

Name the Ground Support Job

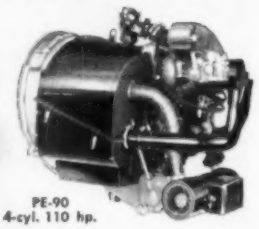
...there is a PACKETTE to Do it.....and a PACKETTE Doing it Now!



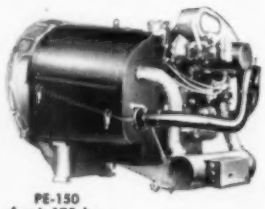
PC-30
2-cyl. 34 hp.



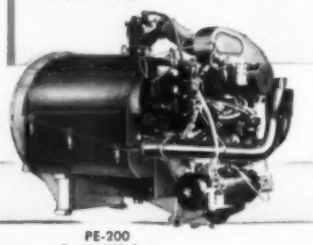
PC-60
4-cyl. 70 h.p.



PE-90
4-cyl. 110 hp.



PE-150
6-cyl. 175 hp.



PE-200
8-cyl. 250 hp.

Air conditioners, crash trucks, compressors, generators, test stands, refuelers, heaters, blowers, Rollagons, multi-purpose trucks—it would be hard to name a type of ground support equipment which one or another of the five Continental Packettes isn't either doing, or equipped to do, better than any other engine. . . . . These Military Standard power plants (Mil. E-6449-A) are approved for use in equipment for all branches of the Armed Forces. Developed by Continental Motors, on whose aircraft engine models they are based, they span an output range from 30 to 250 horsepower. They combine light weight, compactness, and ease of servicing and upkeep with the rugged stamina for which Continental has been known for 56 years. . . . . Packettes are built to operate in any temperature from sizzling desert heat to 65 below zero, power output being automatically governed to the load. They feature unusually wide interchangeability of parts—among themselves and among models in Continental's aircraft engine line—and complete supplies of parts are maintained all over the world.

In short, IF THE APPLICATION FALLS WITHIN THEIR POWER RANGE, NO OTHER POWER PLANT WILL DO THE JOB SO WELL

WRITE FOR COMPLETE INFORMATION

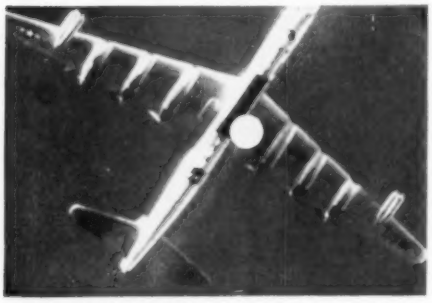
Continental Motors Corporation

AIRCRAFT ENGINE DIVISION

MUSKEGON, MICHIGAN

CAMERAS RECORD NUCLEAR WEAPONS TEST DROPS

At the Atomic Energy Commission's Salton Sea Test Base this special tracking mount uses a 35mm high speed Mitchell camera. Operated by Sandia Corporation, this base uses Mitchell cameras for recording test operations.



Tracking at 40,000 feet, this film frame from a Mitchell camera operating at 96 frames per second provides an accurate record.

Salton Sea Test Base Uses Mitchell Cameras to Capture High Speed Action of Dummy Bombs

High speed flight and laboratory tests, which hitherto have been difficult or impossible to view with the human eye, are today providing revealing information through high speed film recordings.

Typical example of the widespread use of high speed cameras is the Salton Sea Test Base in Southern California, where drop testing of "dummy" bombs is a major activity. In testing carried on there, by Sandia Corporation for the Atomic Energy Commission, as many as 20 Mitchell high speed cameras may record different angles in the flight of an experimental weapon "shape" from drop aircraft to impact area.

Operating at 48 to 100 frames per second, the Mitchell cameras film accurate, steady images with maximum uniformity—even under difficult and complicated filming conditions.

Mitchell cameras play a growing role in today's research and development—just as 16mm and 35mm Mitchell cameras have become the leading professional motion picture equipment used by industry, television, and film studios throughout the world. Write on your letterhead for further information on the uses of Mitchell cameras in the field of military and industrial research.

High speed Mitchell Camera in operation on tracking telescope mount during test run at Salton Sea.

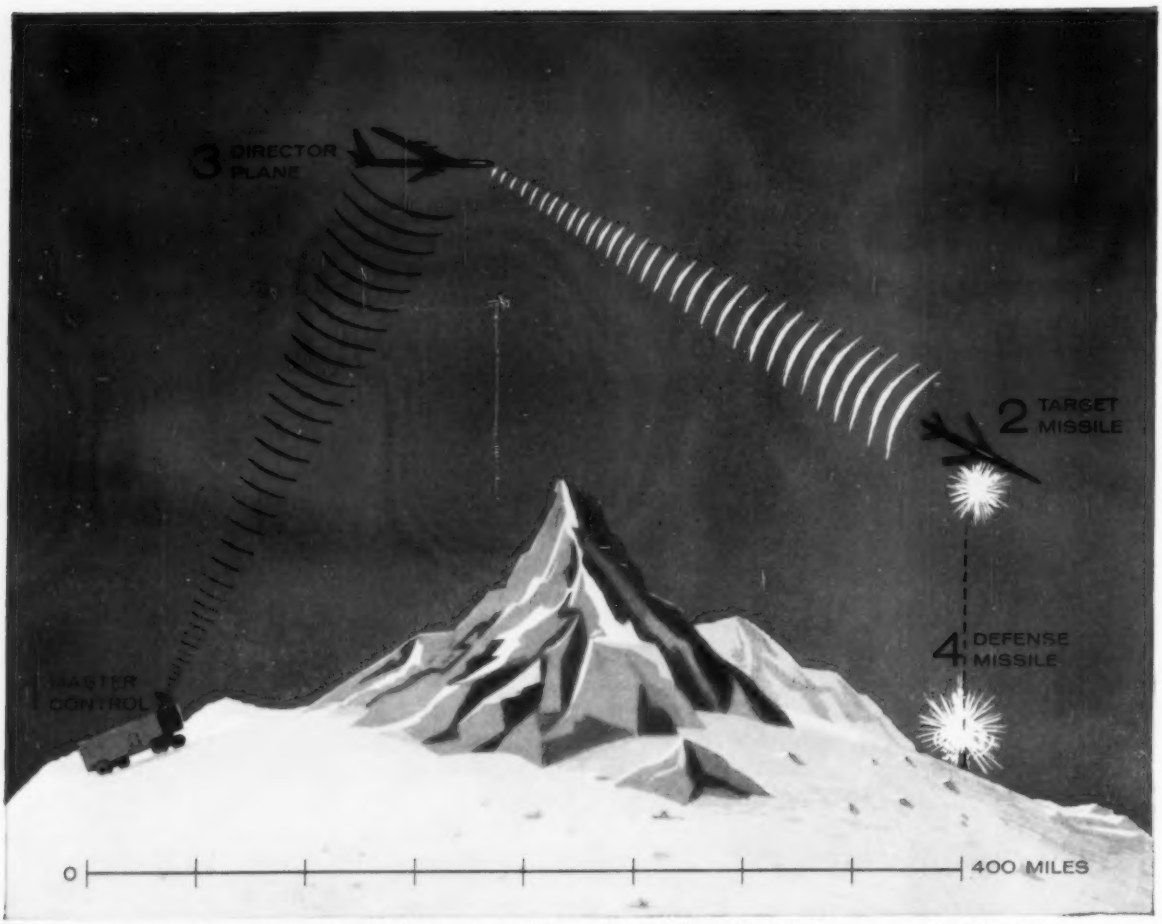
Photogrammetric mounts for 8 Mitchell cameras determine the position in space of a nuclear explosion.

Mitchell Camera

CORPORATION

666 WEST HARVARD STREET
GLENDALE 4 CALIFORNIA

Cable Address: "MITCAMCO"



In action Sperry system, housed in air-transportable trailer (**1**), can command, track and telemeter drone flight data of supersonic target (**2**) either directly or through air director (**3**) when either long range or low altitude is involved. Object is to test readiness of anti-missile defense and accuracy of ground-to-air defense missile (**4**).

DRY RUN FOR USAF ANTI-MISSILE DEFENSE

New Sperry radar guidance system controls drones at 400-mile range

Accurate control of target drone in flight is maintained by operator at microphone through flight instruments on control console. Man in foreground monitors mission. Flight path of distant drone is traced automatically on plotting board at upper right.

A microwave command guidance system designed to help test U. S. defenses against potential enemy weapons has been successfully demonstrated to the Air Force.

Developed by Sperry under contract with the Air Research and Development Command, the system is scheduled for initial use with Q-4A supersonic drones. It is the first command guidance system to be considered for universal use to control other target drones, pilotless aircraft and missiles at high and low altitudes and at great distances.

The system tracks a vehicle, commands its engine and flight controls, and receives flight data—all on a single radar link. At extreme range or in mountainous terrain, the system operates through an air director. Like the master ground control station, this control aircraft is equipped with radar range, tracking, command, plotting and data receiving apparatus. In addition, chain-station operation capability enables long-range drones to be ground-controlled to maximum limits along the range.

This is the latest advance in Sperry's long history in the drone control field. Since 1946 Sperry drone control systems have been applied to many types of aircraft—both reciprocating and jet.

AERONAUTICAL EQUIPMENT DIVISION

SPERRY GYROSCOPE COMPANY

Great Neck, New York

DIVISION OF SPERRY RAND CORPORATION

BROOKLYN • CLEVELAND • NEW ORLEANS • LOS ANGELES • SAN FRANCISCO • SEATTLE; IN CANADA: SPERRY GYROSCOPE COMPANY OF CANADA, LTD., MONTREAL, QUEBEC.

COMPUTERS

DEVELOPED

MANUFACTURED

for 20 years.....
computers and controls

by **LIBRASCOPE**

SOLUTION TO COMPLEX COMPUTING PROBLEMS are among Librascope's accomplishments as represented by a formidable array of computing equipment. Our selection of the most effective computing solution to meet a problem is based on twenty years of experience gained in the development and manufacture of mechanical, electrical, electronic and magnetic computing devices. Computers for both military and commercial purposes are developed and manufactured by Librascope. Inquiries on computing control problems are welcome.

Engineers capable of significant contributions are invited to write Glen Seltzer, Employment Manager.

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LIBRASCOPE, INCORPORATED • 808 WESTERN AVENUE • GLENDALE, CALIFORNIA

Modern defense in action:*

PAINTING BY CHESLEY BONESTELL

The threat...mass bomber attack across the

You are on radar duty at America's Dew Line—near the top of the world – and spot a mass of bombers approaching at supersonic speed. Another Pearl Harbor?

Not likely! Your warning signal alerts a defense system which is in being now. Fighter planes streak out in a matter of minutes, armed with rockets like the Air Force *Genie*—a Douglas built missile which can down an entire bomber formation with one blast.

In addition, our Army is ready for any aircraft that filter through with ground-based Nike Ajax and the still more potent, nuclear-armed Nike Hercules—both produced by Douglas. Radar-guided, these missiles can take out fast aircraft despite all evasive action.

It is no accident that we are now ready for attack from

Defensive systems—Military leaders cannot afford to wait until an enemy strikes. Plans must be in being to meet any contingency . . . any type of attack. And the physical means of meeting this attack . . . vehicles, weapons and trained men . . . must be ready, too!

North Pole

Search radar antenna mounts 24 hour guard at edge of Arctic Circle . . . flashes immediate warning to defense centers

across the North Pole. Such problems were anticipated by our Army, Navy and Air Force planners years ago. Industry became their partner in finding a solution. Douglas, for example, was asked to develop Nike in 1945, and has been working on rockets since before Pearl Harbor—in 1941. This same forethought is in action right now, perfecting the systems of defense needed against tomorrow's aggressors.

Depend on

DOUGLAS

first in Missiles

©1958, R-S Corp.

Whenever, wherever trouble flares...

STRAC WHEELS INTO ACTION!

STRAC, the new Strategic Army Corps . . . our tough, "trouble-shooting" fighting force . . . stands ready, night and day, to speed into combat by land, sea, and air.

In today's brand of warfare, STRAC must be equipped with vehicles that can move men, guns and equipment anywhere. Helping to meet rigid military requirements like these has been a major project of Timken-Detroit® *engineering* for nearly 50 years.

Today we are working with prime contractors and the Department of Defense in designing, developing and producing axles and gear boxes for many types of military rolling stock.

If you are a designer or builder of military vehicles – or if you design equipment to handle, transport and launch missiles and rockets – the benefits of our broad experience and facilities are available to you. Write or call us. We will gladly help you solve any power transmission problem.

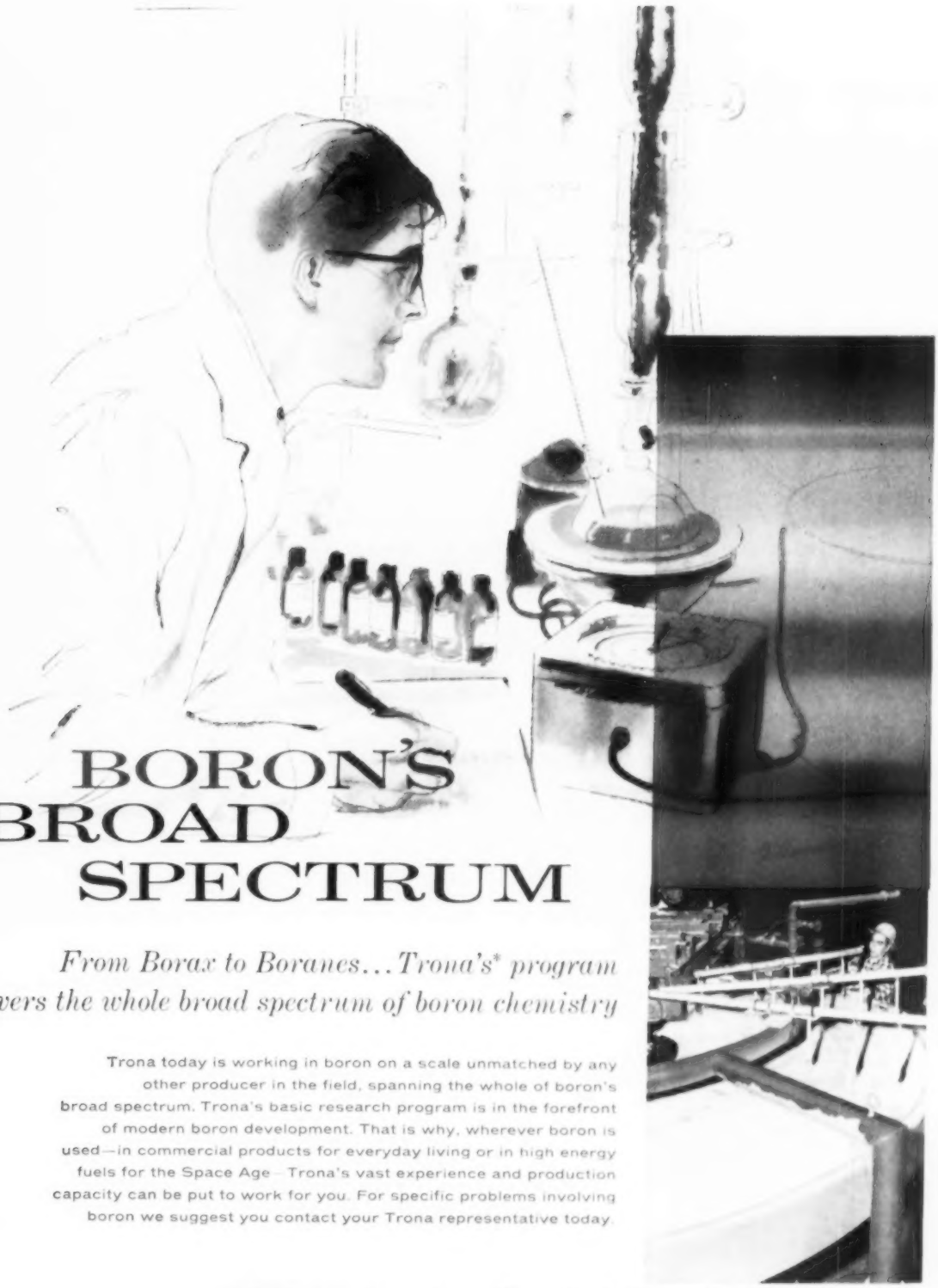
Plants at: Detroit, Michigan
Oshkosh, Wisconsin • Kenton and Newark, Ohio
New Castle, Pennsylvania

TIMKEN Detroit AXLES
ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

The Accepted Standard

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSES AND TRAILERS

Products of **ROCKWELL-STANDARD** Corporation



BORON'S BROAD SPECTRUM

From Borax to Boranes... Trona's program covers the whole broad spectrum of boron chemistry*

Trona today is working in boron on a scale unmatched by any other producer in the field, spanning the whole of boron's broad spectrum. Trona's basic research program is in the forefront of modern boron development. That is why, wherever boron is used—in commercial products for everyday living or in high energy fuels for the Space Age—Trona's vast experience and production capacity can be put to work for you. For specific problems involving boron we suggest you contact your Trona representative today.

*TRADENAME AND TRADEMARK OF APACO

TRONA **American Potash & Chemical Corporation**

3000 WEST SIXTH STREET, LOS ANGELES 54, CALIFORNIA

OFFICES: LOS ANGELES, NEW YORK, CHICAGO, SAN FRANCISCO, PORTLAND (ORE.), ATLANTA, COLUMBUS (O.), SHREVEPORT

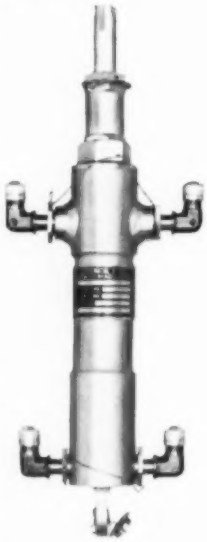
Other Trona Boron chemicals: BORAX (DECAHYDRATE, PENTAHYDRATE, ANHYDROUS) • BORIC ACID • SODIUM BIPERBORATE • BORIC OXIDE ELEMENTAL BORON • TRIMETHYL BORATE • TRIMETHOXYBOROXINE • BORON TRICHLORIDE • BORON TRIFLUORIDE • LITHIUM TETRABORATE *also* CESIUM • RARE EARTH • AND THORIUM BORIDES

NEED RESEARCH AND DEVELOPMENT?

put the
KETT ***TECHNICAL CENTER***
to work for you.

Here's a Sample of Kett Ability

The Kett hydraulic actuator controls the position of jet engine variable exhaust nozzles. The actuator develops a force of over 2,200 lbs. and has been tested for 20,000 cycles at 3,000 psi operating pressure and at temperatures up to 500° F. It is completely sealed against external leakage and it has a special locking device incorporated as a safety measure against hydraulic failure.



How Kett Can Serve You

The hydraulic actuator described here is just one example of the resourcefulness of Kett scientists, engineers and technicians. This staff has successfully completed a number of important studies and projects in the aeronautical, nuclear, electronic and mechanical fields. Complete facilities for Research and Development work as well as for the production of pilot models are available to you at Kett. You will find here the experience and trained personnel to help you develop a new product or to modify or improve your existing products. We welcome a discussion of your problem. No obligation, of course.

Write for brochure showing Kett and U. S. Industries, Inc. Facilities.

OPENINGS FOR RESEARCH ENGINEERS. SEND QUALIFICATIONS TO PERSONNEL DIRECTOR, KETT TECHNICAL CENTER.

KETT *Technical Center, Inc.*

POMPANO BEACH, FLORIDA

a Subsidiary of U.S. INDUSTRIES, Inc. USI®

ATOMIC ENERGY

Nuclear Propulsion

The Atomic Energy Commission recently announced the completion of the assembly of an experimental reactor to be used in Project Rover, a study by Los Alamos Scientific Laboratory to determine the feasibility of nuclear power for rocket propulsion. The reactor, known as Kiwi-A, will be tested late this year in initial static ground experiments at the Nevada Test Site.

Kiwi-A, named for the flightless New Zealand bird, was assembled without nuclear components at the Commission's South Albuquerque (N. Mex.) Works by technicians of Los Alamos and ACF Industries, Inc. It was disassembled preparatory to shipment to the Nevada Test Site, where it will be reassembled with the nuclear components at the Project Rover experimental facilities.

The Advanced Research Projects Agency also announced recently that the Air Research and Development Command has been authorized to let a feasibility study contract with General Dynamics Corporation's General Atomic Division, San Diego, Calif., related to the possible development of a new concept of propulsion employing controlled nuclear explosions.

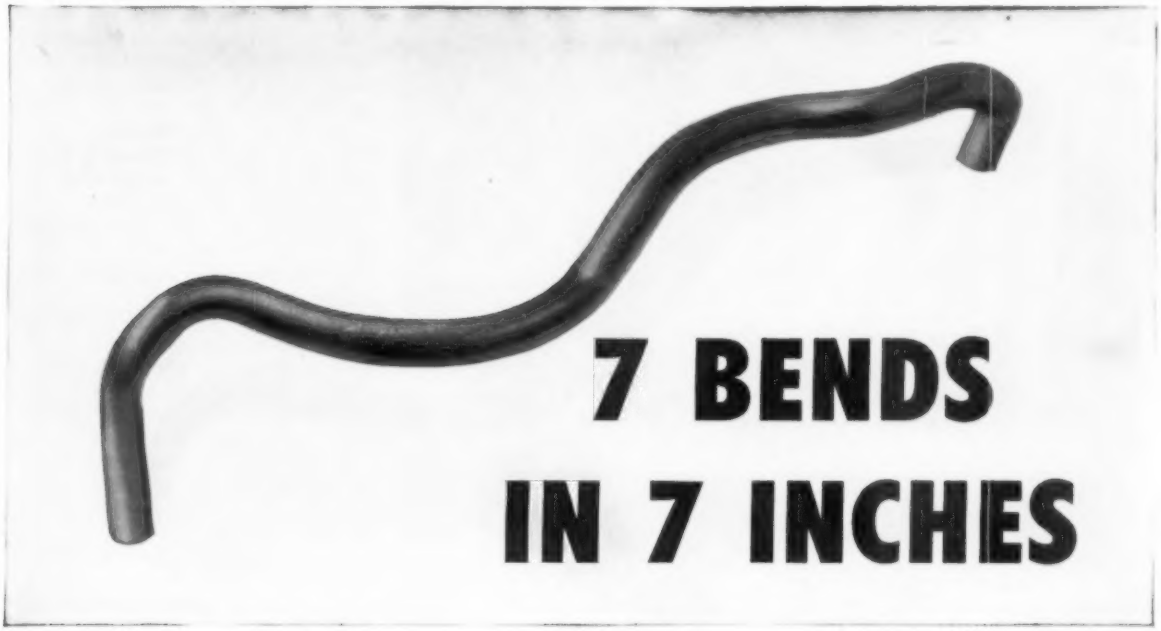
This is one of a series of investigations involving new means of propulsion for space applications. Conceptually this study, which was proposed by General Atomic, differs from other proposals under consideration in that it looks to the employment of a series of controlled detonations within the atmosphere and beyond. The initial commitment for this study calls for the expenditure of one million dollars during fiscal year 1959. Continuation of the program will be based upon the results of the study during the initial phase.

Reactor Safety "Fuse"

A reactor safety "fuse," which automatically shuts down high-power nuclear research reactors if operating control is lost, has been designed, built, and successfully tested for the Atomic Energy Commission by Atomics International, a division of North American Aviation, Inc.

The fuse was tested recently at the Commission's experimental facility, known as Special Power Excursion Reactor Test (SPERT), at the National Reac-

Multiple-bend discharge tube for refrigeration compressor is fabricated economically on Bundy-designed fixtures. Seven bends are put into a 7" length of ¼ x .028" Bundyweld Tubing in just one semi-automatic operation.



Only Bundyweld Tubing could take the stress ...only Bundy could mass-produce the part!

This refrigeration-compressor discharge tube graphically illustrates the unique physical properties of Bundyweld® Tubing . . . and the skill of Bundy® fabrication experts.

Seven bends in just seven inches sets up terrific stresses—too many for ordinary tubing. Yet Bundyweld takes this punishment with ease . . . still stays *leakproof by test!*

Because Bundyweld is double-walled from a single *steel* strip, it's extra-tough . . . has high bursting strength and great resistance to vibration-fatigue. Result: Bundyweld has become the standard of the refrigeration industry; and it's also used on 95% of today's cars, in an average of 20 applications each.

See what you can do with Bundyweld Tubing! Our engineers will help out at any design-stage in the development of your product, from blueprint to assembly. In many cases, they'll have suggestions on how to make a part faster . . . or at lower cost.

And when the design is firmed up, turn it over to Bundy's skilled fabricators and relax. Using Bundy-designed machines and fixtures, they will mass-produce your parts at low unit-cost. Then they'll package your parts carefully . . . deliver them right on schedule – clean, bright and ready to use.

Whatever your tubing needs, Bundyweld Tubing and Bundy services can pay off for you. Find out more. Call, write or wire today!

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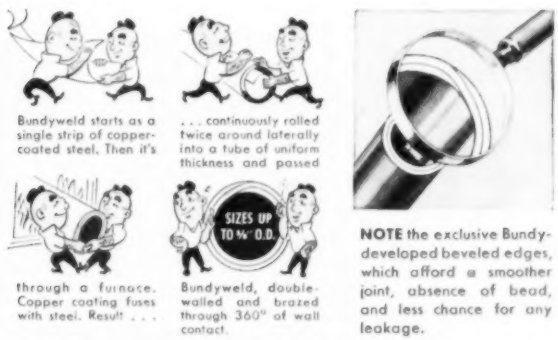
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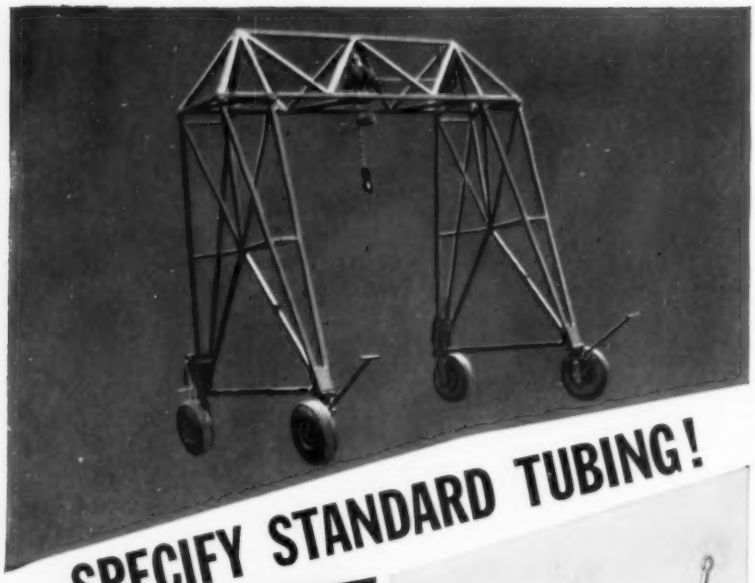

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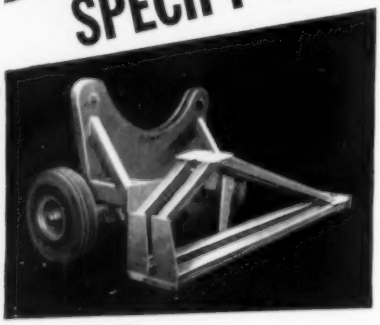

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tor Testing Station in Idaho. It was subjected to severe power surges or "transients." SPERT, operated by Phillips Petroleum Company, was designed to study the characteristics of power surges in nuclear reactors.

The fuse prevented the reactor power from rising excessively during a severe transient in which the rate of power increase was tripling each one-hundredth of a second. The fuse terminated the power surge at a level twenty-five times lower than the reactor would have reached without the device.

The fuse is completely self-contained and requires no operator or external connections. It includes a cylinder, part of which is in the reactor core. The part of the cylinder outside the core contains boron trifluoride gas. In the event of a reactor transient, or an excessively high level of operation, the gas is released automatically into the lower part of the cylinder.

The gas acts as a reactor "poison" by absorbing neutrons needed to maintain the nuclear chain reaction. The gas transfer brings the reactor under control almost instantaneously and without damage.

Uranium Restrictions Lifted

The Atomic Energy Commission has removed prohibitions on nonnuclear uses of uranium and has made depleted uranium from Commission stocks available for sale on an unclassified basis.

Depleted uranium is material from which a part of the fissionable U-235 has been removed; it has less than the seven-tenths of one per cent by weight of uranium 235 present in natural uranium.

The removal of the restrictions on uranium uses will allow U. S. industry to resume industrial applications prohibited since World War II, such as uses in ceramics and glass products, primarily as a coloring agent, and in photographic films, negatives, and prints. Either normal uranium, purchased from private industry, or depleted uranium now available from the Commission, may be used for such purposes. The prewar market in these fields was about 200 tons a year.

Although depleted uranium has been available on a classified basis to U. S. industry since 1955, its declassification allows broader use of the material in the United States and also permits export. It may be sold abroad for peaceful purposes under the terms and conditions available to domestic purchasers, subject to appropriate safeguards against diversion to nonpeaceful uses.

Ship Reactor Development

The Maritime Administration and the Atomic Energy Commission have approved a contract with General Dynamics Corporation for development work in con-

nection with a gas-cooled nuclear power plant for merchant ship propulsion.

The initial phase of the project, which is known as the Maritime Gas-Cooled Reactor (MGCR), includes development of high-temperature fuel elements, reactor controls, and compatible power-generation machinery, and the selection of coolant and moderator. The design, construction, and test operation of a prototype plant are dependent upon successful completion of the development work. It is estimated that the entire program would take from five to seven years.

Studies previously made for the Commission and the Maritime Administration indicate that a gas-cooled type would weigh less than other types of nuclear power plants and would operate safely in ports and at sea. However, the studies also show that further advances in both reactor and gas-turbine technology as covered in the initial phase of the project must be made before the system can be successful.

This development contract is a further step by the Commission and the Maritime Administration toward application of nuclear power to the propulsion of merchant ships. The first nuclear-powered ship, the U.S.S. SAVANNAH, is under construction with completion scheduled for early 1960.

Radiation Hazard Control

Atomic Energy Commission offices throughout the United States are acquainting State and local governmental officials with services the Commission and the Department of Defense have available should an incident involving radiation occur in their local area.

While highly unlikely, it is possible that an accident involving a nuclear reactor or radioactive materials, either in use or in shipment, could result in release of radioactivity in such manner and quantity as to be hazardous to the public. For example, an incident might result from the involvement in a traffic accident of a truck carrying radioactive materials.

For some time the Commission has had in readiness at its various installations radiological personnel for use in helping to protect the public in the event of such incidents. They are trained and equipped to monitor radioactive materials and advise local officials and physicians on the extent of radiation hazards and the steps that should be taken for the further protection of public health and safety, and they have now been integrated into a network.

All areas of the continental United States are covered. In addition, key U.S. military commands have teams especially trained and equipped to assist in protecting public health and safety in case of a radiation incident.

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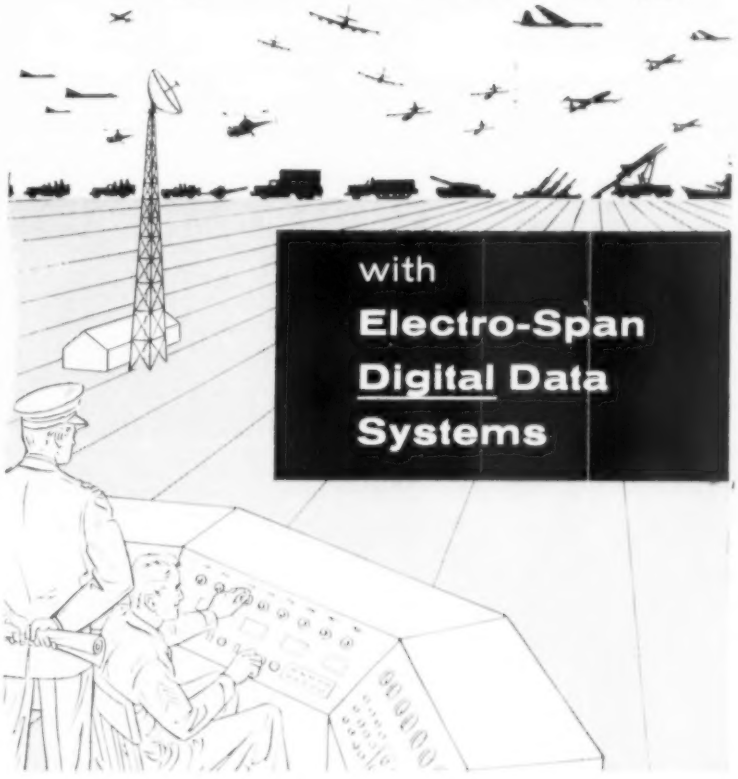

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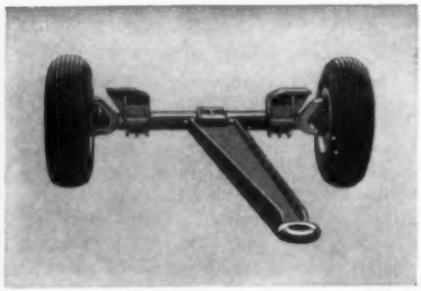
IS IN THE MISSILE GROUND SUPPORT PROGRAM



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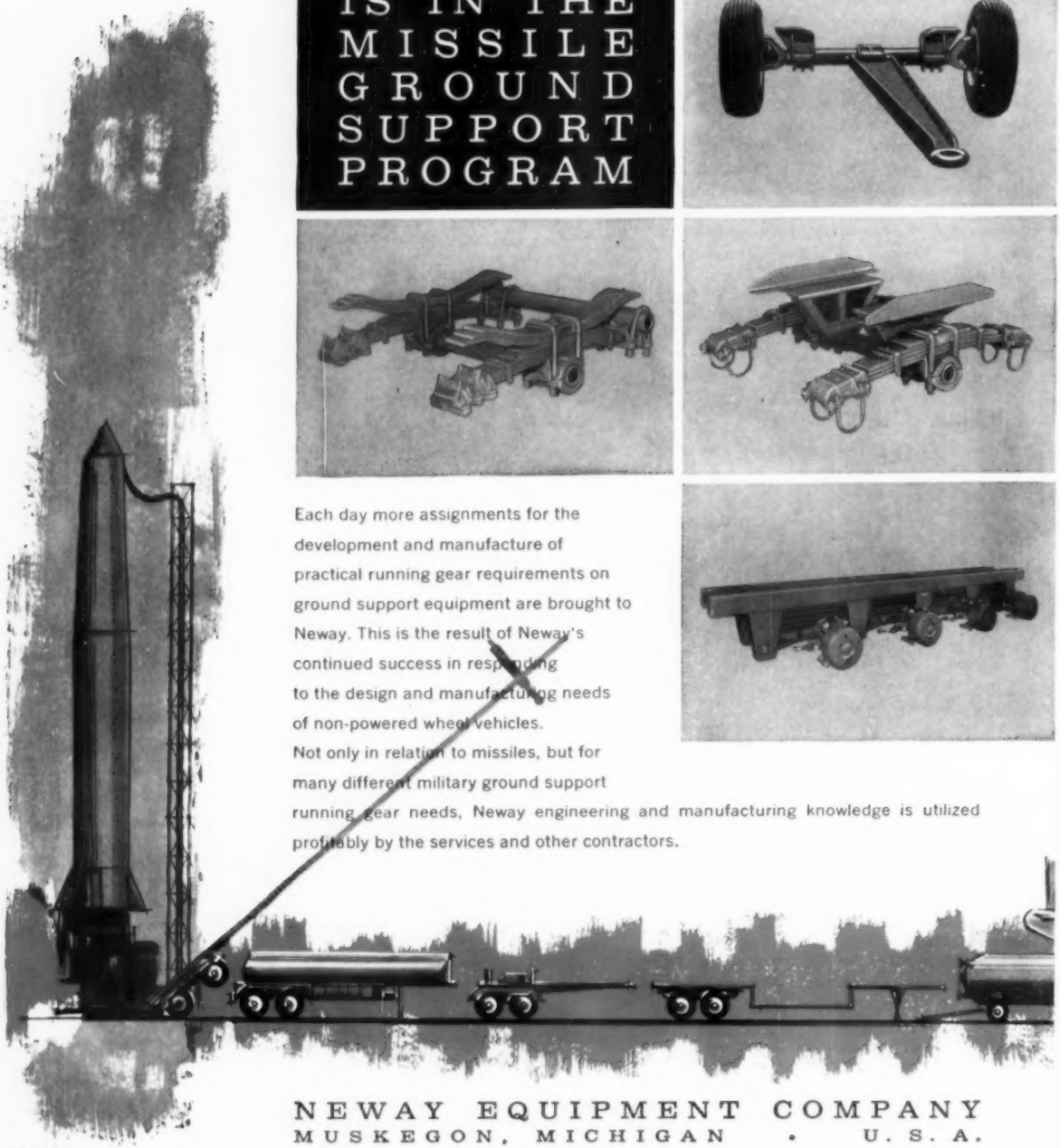

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DR. JAMES R. KILLIAN, JR.

Chairman, President's Advisory Committee on Science

Science for Security

Dr. Killian has the task of guiding the Nation's research efforts

FUNDAMENTAL or basic research is the innermost secret of the rapid technological progress that the world, and especially the United States, has made in the past few years. Yet few seem to understand that Mach 2 aircraft, space missiles, nuclear submarines, and myriad labor-saving devices stem basically from theories propounded many years ago.

Furthermore, the ability to change these theories into useful devices has been proportionate to a rapid growth in smart engineering practices and the number of people sufficiently educated to use and maintain these devices.

For generations, educators and scientists on the whole felt that research could not be controlled or pushed; that researchers would develop naturally; that they were born, not made. Now it is becoming more apparent that, with the unbelievable progress in technical fields, this Nation must leave no stone unturned to maintain the present rate of progress in order to survive.

Yet our progeny undoubtedly will look back with amazement on the fact that the United States, instead of appreciating early the need for a new approach in its scientific endeavors, remained in an educational morass until shaken loose by a Russian sputnik.

IT is no easy task to make the most of our vast scientific and technical capabilities and to ensure that they are properly proportioned to provide for the common defense and promote the general welfare. The first steps in this direction were the formation of the Advanced Research Projects Agency in the Department of Defense and the formulation of plans for a national agency to direct space technology. These efforts, directed primarily at the fascinating field generally covered by the term, astronautics, took priority over the more difficult matter of an adequate long-range national plan for the advancement of science and technology in all fields.

The leader in this broad program is Dr. James R. Killian, Jr., Chairman of the President's Advisory Committee on Science. For over nine months Dr. Killian has brought to bear all the vast experience he gained as the president of the Massachusetts Institute of Technology in arriving at a national plan for science. This has been his principal occupation although he and his team of distinguished scientists assisted in the establishment of ARPA and the recently authorized National Astronautics and Space Agency.

In general terms, Dr. Killian talks of a program to consist of military research and development to keep pace with the changes in military technology, greater emphasis on the qualitative aspects of national research efforts, and increased and continuous emphasis on maintaining an increasing rate of research and development—free from budgetary ups and downs.

IN what manner the national scientific effort will be guided remains to be seen. Our most prominent scientific men seem to feel that it should be directed by an informal cabinet of scientists made up of the principal government officials in this field—possibly led by the President's adviser. There is also in the hopper a Senate bill entitled the Science and Technology Act of 1958 that would establish a Department of Science and Technology with a Secretary of Cabinet rank.

The mere fact that our governmental and scientific leaders appreciate the need for a long-range national scientific plan and are tackling the problem with determination to maintain our world position is a long step ahead.

Our increased awareness that we might fall behind in our technology is indicated not only by the new agencies formed but also by the increased funds recently granted the National Science Foundation, the Defense Department, and the National Bureau of Standards to enable them to pursue a wider field of basic research. In all of this, Dr. Killian has been the guiding genius.

James Robert Killian, Jr., Scientific Adviser to the President, is a distinguished scientist and educator. A native of South Carolina, he was graduated from Massachusetts Institute of Technology in 1926, served there continuously in many capacities, becoming president in 1948.

Dr. Killian's long record of duties at MIT included editor of *The Technology*, the institute's journal, and executive vice-president, and vice-president of the university.

Throughout his career as an academic administrator there has been a constant demand for his wise counsel on many important boards and committees. He was a member of the Science Advisory Committee, Office of Defense Mobilization; Board of Visitors, U. S. Naval Academy; General Motors National Scholarship Board; Ford Scholarship Board; Committee for the White House Conference on Education; and Chairman, Army Science Advisory Panel and President's Board of Consultants on Foreign Intelligence Activities.

Among the many honors he has received, in addition to honorary degrees from over fifteen universities, are the President's Certificate of Merit, Freedom's Foundation Award, and the Certificate of Appreciation, Department of the Army.

Future of Manned Bombers

(Air Force)

Although guided missiles will complement and partially supplant aircraft they will not replace them in the foreseeable future

Gen. Curtis E. LeMay

ON October 4, 1957, the Soviet Union startled the world by launching Sputnik I. A few days later, the *London Dispatch* published extracts of a Moscow interview with Soviet Premier Khrushchev in which he was purported to have said, "Fighter and bomber planes can now be put into museums." Articles soon appeared in newspapers and magazines throughout the United States to the effect that the flying Air Force was finished and that push-button war was around the corner.

A little more than two months later, on December 24, 1957, in a story datelined Moscow *The New York Times* reported that the Soviet Union had successfully tested a new type of heavy jet bomber. A lengthy story about the test flight in the Russian Army newspaper *Krasnaya Zvezda* said the aircraft had set a nonstop distance record, for airplanes of such type, without the aid of in-flight refueling. The new craft was not identified by any number nor was its designer named.

There is an obvious inconsistency between Khrushchev's remark about placing fighter and bomber planes in museums and the subsequent announcement of a new high-performance Russian jet bomber. While the launching of the Sputnik was a significant technical achievement, the Russians evidently are *not* placing all their eggs in the missile basket. This fact is corroborated by their continued heavy military aircraft production and the construction of many additional air bases.

The idea that attacks can be conducted deep within enemy territory without subjecting man to the danger of combat appeals to the imagination. It particularly appeals to the imagination of those men who are training hard and standing by right now to conduct a bomber attack if called upon to do so. Most of the aircraft commanders in our Strategic Air Command have had the experience of attacking targets before. They didn't like it then, and I doubt very much if they would like it again. But these men are training continuously to perform this task because they are needed to get the job done—today and as far into the future as I can see.

Before I go into the reasons why I feel we will continue to need manned bombers, I think a brief analysis of the distinguishing characteristics of the Air Force as a military instrument is in order. Of course, each of the military services has characteristics which make it useful as an instrument of war—and

some of these characteristics are possessed, in varying degrees, by more than one service. However, each service possesses certain predominant characteristics which make it of particular value both in peace and in war.

In all cases, the usefulness of a particular service as one of the United States military instruments is based primarily on its capabilities—*i.e.*, what the service can do best and how and when the particular service can do it. These capabilities, in turn, are reflected, to a great extent, by the predominant characteristics of that particular service.

THE Air Force has four such predominant characteristics which have been proved in three wars. These are: (1) reaction, (2) firepower, (3) penetration, and (4) selectivity. Our job has been, is, and must continue to be continuous improvement of these characteristics.

Some of the qualities that I have mentioned are equally applicable to both the offense and the defense. However, since this article concerns the subject of manned bombers, I will discuss these characteristics only from the aspect of the offense.

The first predominant characteristic of the Air Force as a military instrument is reaction. This feature is inherent in the speed and range we have achieved in our aircraft which enables them to deliver an attack at long distances from their bases in a matter of hours. This reaction also must be quick. If our forces are not to be caught on the ground, our counteroffensive must be in the air and on its way to enemy targets within a matter of minutes.

Our goal is to have one-third of our strategic striking force on the way to its targets within fifteen minutes of initial warning. We now have portions of our strategic manned bomber force on 24-hour alert and capable of becoming airborne and on their way to targets within fifteen minutes.

Additional funds recently appropriated by Congress for this fiscal year and funds we anticipate being appropriated for fiscal year 1959 will provide money for the additional facilities we need to ensure an adequate alert and dispersal posture for our manned bomber force.

General LeMay is Vice Chief of Staff, United States Air Force, Washington, D. C.

It is obvious that our reaction not only must be quick but effective. Effectiveness includes accuracy and reliability. Through long experience, both in actual combat and in training exercises, we know what manned bombers can do. Our current strategic bombers with their well-trained crews are proven weapons.

Since human judgment is aboard, manned bombers also possess great flexibility in the employment of tactics and in the conduct of attacks. Furthermore, having man aboard gives us a recall capability.

The second predominant characteristic of the Air Force is firepower. Inherent in Air Force weapons systems is the capability to employ destructive firepower beyond anything previously known in military history. World War II demonstrated this characteristic even with conventional weapons. The advent of nuclear weapons and higher-performance manned bombers has increased the strength of this feature.

An important part of the Air Force characteristic in this respect is its ability to concentrate firepower on any desired objective. Furthermore, this concentration can be compressed in time due to the speed of the instrument.

When I speak of concentration of firepower, I am not referring solely to mass. I include the capability to select the proper amount of firepower to achieve the desired objective. This is a job that manned bombers can do now. The carrying capacity of the manned bomber and the accuracy with which it can strike its target permit utilization of weapons of the desired yield.

The third predominant Air Force characteristic is penetration. This is also inherent in the speed, range, altitude, and the wide variety of tactics of our offensive power which can reach into the very heartland of the enemy. The development of a capability to penetrate anywhere within enemy territory has been a primary goal of the United States Air Force since the development of the first bomber aircraft. Our strategic jet bomber force supported by its tankers possesses a current capability to attack anywhere in the world on short notice. Our worldwide airbase structure complements this capability.

Getting the bombs "on target" has called for many changes in techniques and tactics to achieve greater accuracy and to counter improved defensive measures. For example, in World War II the first attempt to use guided bombs was made. The first experiment was the so-called "Azon" bomb which was a free-falling bomb that could be controlled by the bombardier in azimuth after it had been dropped.

Following closely upon this was the "Razon." This also was a free-falling bomb which could be controlled in azimuth and slightly in range. In both cases, however, the bomber was committed to flying a predesignated course while the bomb was controlled by the bombardier. This, of course, increased the vulnerability of the bomber to both fighter and antiaircraft attack.

DEVELOPMENT of a bomb or missile which could be launched at some distance from the target, the farther away the better, and still possess a high order of accuracy has been the bomber pilot's dream for years. Such a weapon would complicate the defense problem and greatly reduce the vulnerability of the piloted bomber. Air-launched missiles of this type have been under development for some time. One such missile, the Rascal, is now in production. It is rocket-powered, supersonic, and can carry a nuclear warhead.

Missiles like these are adaptable to a variety of tactics. For example, they can be released miles from the objective while the bomber remains outside the heavily defended area, or they can be used as a penetration aid for the purpose of disrupting enemy defenses while the bombers proceed to their targets. Eventually, we anticipate that piloted bombers will be able to launch air-to-surface missiles against critical

The B-58 "Hustler," pencil-thin, delta-winged supersonic bomber is powered by four jets (Air Force photo).

targets as far as a thousand miles distant.

Selectivity is the fourth predominant characteristic of the Air Force instrument. The speed and range of manned bombers and the wide range of tactics which can be employed permit great flexibility of operations. Attacks can be initiated or broken off as desired. They can be self-sufficient or employed in conjunction with other forces. Attacks can be conducted against the periphery or deep within enemy territory. Attacks also can be conducted from many different directions at once and successfully against targets of uncertain locations.

IT is somewhat surprising to realize that most targets are targets of uncertain location. In most cases, of course, we have a good idea of the general location—within a few miles, for example. Such information is sufficient data for a successful manned bomber attack using visual or radar bombing methods. But general location is not sufficient information for accurate missile attack. This point was brought home, as recently as Korea, where we had difficulty with our B-29 Shoran operations because we did not know the precise location of certain targets.

Shoran bombing was used for night bombing operations against targets that had little or no radar return. Shoran operations can be compared, in theory, to missile operations in that the bomb run (the attack) is directed by ground guidance stations located in friendly territory against a "known" target.

We had this difficulty, despite the fact that our fighters were flying over the targets daily and photographing them at will. Extensive computations based on a variety of available data were required to solve the problem—and the problem was "precise target location." Before we could get our bombs "on target" we had to determine *precisely* where the targets were located on the geographical face of the earth.

It should be obvious that many targets deep in an enemy's heartland would pose a similar problem in a missile attack despite the great destructive power of the nuclear warheads that could be employed.

Before manned bombers can be *completely* replaced with unpiloted systems, unpiloted systems must possess *all* the characteristics I have mentioned. Until they do, manned bombers cannot be replaced.

In the development of our long-range missiles, we are striving hard to meet the required characteristics. We cannot afford long countdowns, for example, if we are to be capable of *quick* reaction.

Recent break-throughs in the solid-propellant field foreshadow great improvement in the strategic missile reaction capability. Through the development of missiles of varied performance, we are trying to achieve proper penetration capabilities. Target locations are also being checked and rechecked and maps are being analyzed and verified.

Missile accuracy and reliability and the development of missile warheads with adequate firepower potential are other important factors under continuous study in an attempt to achieve greater selectivity.

Despite the technical advances being made and those we look forward to achieving in the future, I still do not envision that missiles will completely replace the piloted bombers. Missiles will, of course, have advantages in many situations, and we *must* have them.

BUT the force that will prove to be the effective force in the future will be an integrated force composed of piloted and unpiloted systems. In this way, we can best utilize the outstanding features of both systems. A force composed of both piloted and unpiloted systems working together in compatible and complementary rôles will be the best force.

There is a certain and constant inflexibility in intercontinental ballistic missile operations. As I mentioned pre-

viously, inflexibility is inherent in the requirement for precise geographical relationships between a missile's launch site and the accuracy of target locations. Inflexibility also exists in the inability to recall a ballistic missile once it is launched, in the inability to divert the missile from one target to another while in flight, and in the missile's known trajectory which eases the defense problem.

WHEN target values or defensive measures call for a change in strategy or tactics—as they frequently do in war—the attack must be realigned. For this reason, if for no other, missiles must be complemented by other weapons with a greater degree of flexibilty. That other weapon as of right now and far into the future will be the manned bomber.

As most informed Americans know, our strategic force today consists of B-36's, B-47's, and B-52's. The B-36 is being phased out of the picture as rapidly as B-52's come off the production line. When the last B-36 phases out, we will have an all-jet strategic striking force. This force supported by its tankers and carrying nuclear weapons can strike targets effectively anywhere in the world.

We are well aware that the defense against these bombers would be rugged, but through the employment of a variety of tactics, the use of electronic countermeasures, and newly developed air-to-surface missiles we know that the job could be done if needed.

The Rascal, which I mentioned earlier, will be the air-to-surface missile carried by the B-47. The Hound Dog air-to-surface missile is under development for use by the B-52's. The latter is a more sophisticated and longer-range weapon than is the Rascal.

In addition to these air-to-surface missiles which will be carried by the attacking bombers, we also have under development various ground- and air-launched decoys which will be used to confuse and saturate enemy defenses.

Two new bombers which we have under development, the B-70 chemical bomber, which will be capable of speeds on the order of 2,000 miles an hour, and the nuclear bomber which will be capable of extended range, will add greatly to the potential of our manned bomber force. Piloted craft such as these, further development of air-to-surface missiles, and the employment of surface-to-surface long-range strategic missiles in both the air-breathing and ballistic categories will provide a most formidable force.

As far as manned bombers are concerned, there are some very interesting possibilities using these aircraft and long-range air-to-surface missiles. One such possibility is to maintain constant combat patrol of the free world skies.

Looking further into the future, the Air Force has under development the Dyna-Soar, the first "space bomber," which will be capable of circumnavigating the earth at extreme altitudes and attacking its target with space-to-surface missiles.

To achieve success, we must always have the capability to exploit the predominant characteristics of airpower. To do that job in the most effective manner will continue to require men. Man's intelligence, skills, and judgment are not parts of the unpiloted missile system.

WHEN Mr. Khrushchev stated that fighter and bomber aircraft could be put in museums, I feel that he had his tongue in his cheek. We already have fighter and bomber planes in museums in this country.

But the day you stroll into a museum to see a B-52 or a B-70 or even a nuclear bomber, it will not be because man has been eliminated as a direct participant. It will be because new equipment has been perfected to propel him higher, drive him faster, keep him in motion longer, and so enable him to perform more tasks better.

The most reliable and yet the lightest weight guidance system we have is man. Should a more reliable and lighter weight system be developed, it will still lack judgment. And judgment is essential in war.

The eight-jet B-52 Stratofortress heavy strategic bomber (Air Force photo).

Can We Stay in Europe?

We must develop a retaliatory force removed from centers of population and with sufficient firepower to nullify surprise attack

Maj. George Fielding Eliot

THERE is only one reason for the continued presence of American military forces in Europe. That reason is the continued threat to the security of the free peoples of Western Europe—and hence to the security of the United States and the whole Atlantic community of free nations—represented by the aggressive policies of the Soviet Government.

THE basic motivation of Soviet leadership is the expansion of its power. As Lieut. Col. Howard L. Flechlin, U. S. Army, points out in the June issue of the *Military Review*, the entire Communist system "has become a drive for absolute power. Its object is possession of *all* power, not only direct political power but all social, economic, and political power. Therefore it aims to destroy all rivals for power of any kind. . . In fact, Communism may be defined as a worldwide conspiratorial movement for the conquest of a monopoly of power."

The Soviet concept of national "security," Colonel Flechlin continues, "in effect means the unequivocal elimination of any possible external threat to the continued existence of the Soviet regime." The result is a relentless hostility toward all non-Communist states; a hostility based on the realization that the Soviet leadership is itself the rule of a minority which has gained and retains power in Russia and other countries by ruthless organized violence and knows that it must continue to expand its power or perish.

For, in the view attributed to Secretary of State John Foster Dulles by Richard Wilson of *Look*, "the tyranny of Marxist doctrine cannot be adapted to the problems of a growing industrial society and international intercourse . . . Change is inevitable. . . Communism cannot logically prevail against the competition of the principles of individualism, individual opportunity, and personal incentive." Therefore, it must prevail by force—or not at all.

Lenin put the conclusion starkly: "In the end, one or the other must conquer." His successors face the choice Lenin foresaw—they must eliminate all opposition or give way to others prepared to live and let live.

THE possession of nuclear weapons by such a regime, facing such a prospect, is the kernel of the free world's present danger. The possession of nuclear weapons by the United States and other free nations is the chief effective restraint on the Soviet march toward a monopoly of power.

So considered, the immediate Soviet objective becomes clear. It is the elimination of the threat represented by the capabilities of the United States for nuclear retaliation.

Those capabilities as of the present moment are in large part established in our system of overseas bases from which the medium-range aircraft of the Strategic Air Command can reach Soviet targets. Many of these bases are in

the western portion of Continental Europe and in the British Isles. All are within the reach of nuclear fire from Soviet intermediate-range ballistic missiles, as will be the American missile bases which it is now proposed to emplace in these areas.

As the number of the Soviet IRBM's is likely to increase much more rapidly than the number of our air and missile bases in allied territory, the future prospects of allied security may well seem increasingly somber.

It is against this background that the Soviets have been presenting the admixture of threats and blandishments by which they have been trying to get us out of Europe altogether. The tempo of their effort has been steadily rising.

Like Cato the Elder, who used to conclude every speech he made in the Roman Senate, on whatever subject, with the words, "Also it is my opinion that Carthage must be destroyed," the Kremlin can scarcely address a diplomatic note on any subject to a western European state without calling attention to the "consequences" of allowing American bases or forces on that country's soil.

THIS unrelenting Soviet pressure has not been without effect. It is the source of much of the anxiety in Western Europe for a "summit" conference —and of the wishful determination to believe that such a conference might somehow mitigate the threat of war. The nature of partisan politics being not much different in European democracies than in our own, this agitation has been the theme song of opposition parties in elections and by-elections from Britain to Bavaria—a theme not always presented with responsible restraint.

There has been a regrettable tendency toward criticism of the United States as being blind, stubborn, and inflexible —to equate Washington and Moscow as sharers of the "blame" for the sorry state of affairs which is so disturbing to peaceful people.

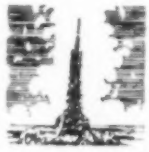
Former President Herbert Hoover, in a recent speech at Brussels, felt it necessary to invite the attention of his listeners to this trend and to point out that such reckless abuse of American motives and conduct was giving rise to a dangerous reaction in America, to a drift toward isolationism, a desire to have done with the exasperating frustrations of collective security.

This article by the distinguished military analyst for the Mutual Broadcasting Company and naval correspondent with General Features Syndicate is a forthright exposition of a pressing immediate problem. It indicates that only visible, unchallengeable American fighting power will convince many people that Communism is not the "wave of the future."

In this connection, readers are referred to an excellent study by Major Eliot, recently published by the United States Naval Institute. It is his book entitled, "Victory Without War 1958-1961." Interested readers will find in it details of his views on sea-based weapons and their function in adding mobility in conventional as well as nuclear battle.*

This latter tendency is accentuated by the suspicion, widely held in this country and often finding public expression in Congress and elsewhere, that at least some of our European allies are not pulling their weight in the NATO boat.

The reductions in the British defense budget, one result of which has been the whittling away of the British air and ground forces in Germany; the virtual vacuum of French military power in Europe, produced by French preoccupation with the Algerian revolt and by the inability of successive French governments to find any solution to that problem; the slow progress of West German rearmament coupled with uncertainty as to future German policy because of the advancing years of Chancellor Adenauer; the troubles in Cyprus which have involved Britain, Greece, and Turkey in a tangle of cross-purposes—all these and many lesser worries cause some Americans to wonder whether we can stay in Europe and others to wonder whether it is worth our while to try to do so.



Upon all these themes the Kremlin propagandists play with a persistence which, fortunately for us all, is not always matched by delicacy and skill. Even so, we have to pause every now and then to remind ourselves that they are still the implacable enemy of all we hold dear; that Khrushchev and Company still practice the philosophy of Lenin's teachings and hopefully cherish his advice:

"WE must use the antagonism between the existing systems of capitalism in such a way as to set one against the other. But as soon as we are strong enough to defeat capitalism as a whole, we shall immediately take it by the scruff of the neck."

In the end, one or the other must conquer. To this purpose—the conquest of a monopoly of power which can never be gained by any means but force —all the tortuous plannings of the Communists must come at last. Upon the defeat of this purpose, all the hopes of freedom are staked.

So we return—we are compelled to return—to the stern consideration of the military balance of forces. It is to keep this balance in our favor that we are in Europe. It is to tilt it in their favor that the Communists want us out of Europe. Without our presence there, the preponderance of the Soviet Army and tactical air force over the opposition that the free European states could offer would be overwhelming.

Do the five American divisons of the Seventh Army make all this difference, then? Not, certainly, in numerical terms. What their presence and that of their supporting air and missile units has done, so far, is to preserve the climate of European confidence in American intentions.

In the persons of our troops and airmen we share the risks of the peoples who must live on the same continent with the Soviet colossus. By their presence we assure our European allies that we will indeed, as the words of the treaty say, regard an armed attack upon

* "Victory Without War 1958-1961." By George Fielding Eliot. Annapolis: United States Naval Institute. $2.00. To members of the American Ordnance Association, $1.80.

one of them as an attack upon ourselves.

Without that presence, that visible presence, the written words would be far less generative of confidence in the reaction of some future American government faced with the terrible decision of launching nuclear war.

To that point too, we must keep returning; for it is not our five divisions by themselves which would stop the Soviet colossus if it began to move westward—and the Europeans know this well enough. What will stop the Soviet armies is the cold, iron fingers of fear clutching the minds of those who must give the order to march. Once that order is given, with American troops in the path of the advancing hordes, the Soviet Union is at war with the United States.

THERE are, no doubt, Europeans who would be uncertain as to whether or not some future American government of unknown political complexion might abandon its allies in such a case. Few Europeans will believe that any American government would dare to abandon 200,000 American officers and men to face hopeless odds without striking at the heartland of the aggressor.

But, of course, the Soviets will not believe this either.

Therefore it is becoming unrealistic, as we enter the missile age, to go on thinking in such simple terms as a Soviet march against Western Europe followed by American nuclear retaliation against the Soviet vital centers. If any such march takes place, it will be accompanied—or rather, preceded—by a Soviet surprise missile attack against the bases from which American nuclear retaliation must come if it is to come at all.

When the Soviet leaders embark on a course of action which involves the loosing of nuclear violence, they are not going to allow the other side to strike the first nuclear blows. In fact they are going to try to make sure that the other side strikes no nuclear blows whatever, or at least that any it does strike shall be no more than the feeble and fragmentary dying efforts of a foe already mortally wounded.

Some European analysts, fixing their minds upon this aspect of the problem, have conjured up a relatively comforting picture of the two giants, the United States and the U.S.S.R., exchanging nuclear attacks by airplane and missile over the heads of the West Europeans, who would merely await with bated breath the outcome of the struggle and perhaps survive to pick up the pieces and reshape the world closer to their hearts' desire.

Others, more realistic, understand that no nuclear attack makes sense unless it is launched by surprise, with the nuclear bases of the opposing side as its primary targets. There is no gain for either side in an *exchange* of nuclear weapons.

FROM this latter consideration comes the current crop of European anxieties. For since neither the United States nor the U.S.S.R. has today a nuclear delivery capacity of *intercontinental* range which is sufficient by itself to be decisive, it follows that a large part of any Soviet surprise assault must be delivered against the medium-range air and missile bases of the United States in western Europe and North Africa.

To attain the capability of destroying these bases is indeed the obvious purpose of the Soviet intermediate-range missile program, now well advanced. When this Soviet capability has been supplemented by enough intercontinental capability to wipe out by surprise the bases used by our intercontinental aircraft and missiles in North America, the stage will be set for the great attack

Submarines provide a movable base for the launching of the Regulus II long-range missile.

—or for progressive blackmail based on our reluctance to face the consequences of resistance.

Neither prospect has any appeal for the free peoples of Western Europe. They see themselves either the helpless victims of a surprise Soviet attack on our overseas bases, or abandoned by us because we are unwilling to face the threat of Soviet attack on our home bases. Yet they see no way to escape from this horrible dilemma. Reams of speculation have been written about "nuclear stalemate" in which neither side dares to start nuclear war, and in consequence such wars as may take place are settled by forces using non-nuclear weapons.

BUT then there arises the specter of the "tactical" nuclear weapons, which we have repeatedly put forward as the "equalizer" with which we would make up for inferiority of numbers on the ground. In the crowded terrain of thickly populated Europe, how is any distinction to be drawn between "big" and "little" nuclear weapons?

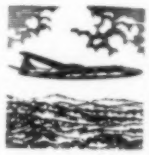
Who will put his faith in the idea that the Soviets, having had a division or two wiped out by "little" tactical bombs, will fail to retaliate with bigger ones? The argument hardly needs to be pursued further to make clear how unconvincing and uncomforting it is.

Yet the Soviets continue on their parallel lines of march—building more missiles and launching more threats. The ballistic missile has no purpose and no value as a weapon except for a surprise attack against a fixed target. The Soviet intentions, therefore, could hardly be made plainer than by their heavy and expanding investment in these weapons.

Out of the fears and frustrations thus aroused in the minds of their Western neighbors come a welter of reactions—protests against American missile bases (to which a recent survey showed the majority of Western Europe's inhabitants to be opposed), demands for a summit conference, exaggerated interest in such Soviet diversionary maneuvers as "disengagement" or protests about the alert procedures of our Strategic Air Command.

Yet there is an undercurrent of European realism which grasps the central fact that such safety as is attainable for the free world lies in making the certainty of retaliation a living and ever-present fear in the minds of the Soviet leadership.

It is this fact that the British Defense Minister comes to as he seeks to concentrate his scanty funds on expanding the British nuclear program and confining defense to the air and missile bases from which British retaliation would have to be launched. It is this fact of which General de Gaulle is surely thinking as he insists that France must have nuclear weapons.



It is this fact—and our implementation of it—on which we Americans must depend, not only for our own security against nuclear attack but for retaining the confidence of our allies and the unity of the free world in the face of Soviet menaces.

What is needed for our implementation of this central truth is a retaliatory force sufficient in volume of fire to destroy the Soviet Union's capacity to make war, and so based that it cannot be wiped out in any surprise attack by the Soviet ballistic missiles—so based, also, that any Soviet attempt to destroy it does not involve, as a dreadful corollary, the extinction of friendly populations.

The only available bases which combine these requirements—capacity to support the weights of nuclear weapons and delivery systems, immunity to surprise destruction by ballistic missiles, and separation from populated regions—are mobile, floating bases *at sea*.

Either airplanes or missiles of high power can be operated from mobile sea bases. The mobility of such bases gives them assurance against attack by ballistic missiles, which must be preset to strike fixed target of known location. Mobility likewise gives a reasonable immunity from *surprise* destruction by any other known means, since the attack and defense of naval units are a matter of search, tracking, approach, and the chances of battle. Finally, the sea is not inhabited by human beings.

As we progress into the ballistic missile era, all *fixed* retaliatory capability suffers a lessening of the survival coefficient. It follows that *mobile* retaliatory capability enjoys a relatively rising survival factor. These two facts, coupled with the facts of geography and the ranges attained and attainable by sea-based weapons, lead to the very logical conclusion that the real deterrent of the future is to be found in seapower.

Once these facts have soaked in, the allocation of priorities in accordance with them will produce for us a sufficiently rapid transfer of retaliatory power into mobile sea bases to maintain our deterrent force at the required level to continue to impose prohibitive risks on Soviet contemplation of nuclear assaults. To summarize:

1. We are rapidly approaching a situation, as the Soviet missile threat expands, when the continued presence of our troops and tactical-support forces in Europe will make sense only if the Soviets continue to be confronted, in addition, by a nuclear deterrent force which is relatively immune to surprise.

2. In the absence of such a deterrent force, other American military units and installations in Europe will increasingly be the objects of Soviet threats.

3. A deterrent force of the required qualities must be based on the principle of mobility. Fixed bases, in the missile age, are obsolete. Under existing conditions, both of geography and of weapons development, the sea affords us the only available operating area for the deployment of a mobile force of the required characteristics.

4. Sea-based forces canot be destroyed or neutralized within calculable time limits, so the Soviets cannot count on escaping devastating nuclear retaliation for any surprise missile attack launched against the United States or its allies. The risk factor in Soviet calculations therefore remains prohibitive.

5. Our continued possession of an effective and relatively invulnerable nuclear deterrent is the cornerstone of allied unity and of the confidence on which such unity must be based.

Army Ordnance Arsenals

An appraisal by the Chief of Ordnance of the United States Army of an essential part of our national defense system to assure the most effective use of the Ordnance-Science-Industry Team

Maj. Gen. J. H. Hinrichs

This article was presented as a statement by the Chief of Ordnance of the Army to a special committee of the House Armed Services Committee. It is an authoritative description of the place our arsenals have held and continue to hold in the over-all plans for the continued cooperation with American science and industry for the design and pilot-line production of superior weapons for our fighting forces.—EDITOR.

MR. Chairman: It is a privilege for me to appear before you as a proponent of the Army arsenal system, because I feel strongly that it is an essential—a vital—part of our national defense system. I want to give you the current context against which I believe any discussion of the arsenals must be taken in order to ensure proper perspective.

The job of the Chief of Ordnance, in its simplest terms, is to design, procure, supply, and service Ordnance matériel —such as guns, rockets, missiles, and ammunition for firepower and tanks for mobility. These are lethal weapons, not commercial items.

Much of this job is accomplished through the coöperative efforts of the Ordnance-Industry-Science Team. Each member of that team has an active and positive part to play. The Ordnance Corps must develop and maintain the managerial, scientific, engineering, and technical capabilities to direct this team effort in behalf of the Department of the Army and fully utilize industry and science in the best interest of the Government. This capability is developed and maintained in the Ordnance arsenals.

THE arsenals have five primary missions to perform for the Army and the Nation:

1. To evaluate and make recommendations concerning desired military characteristics, in terms of technical feasibility, complexity, and logistical implications.

2. To control at all times the quality and performance of matériel through the design, development, engineering, and production phases.

3. To provide capabilities to meet stated mobilization requirements, including furnishing to industry the leadership which keeps the art of military matériel production abreast of the military requirements and demands and, at the same time, consistent with scientific capabilities.

4. To serve as a repository of this munitions and armament knowledge and art during peacetime periods and periods of greatly reduced procurement activity.

5. To perform crash production to fill the inevitable gaps which appear in the production program at the outset of any national emergency or to produce those urgently needed items or components which cannot be procured on a timely or economical basis from private industry.

To do these jobs, Ordnance people must be ahead of the state of the art in most instances (and they generally are) and never less than abreast of it.

WHY is this so? With this competence in our people, and with the laboratory equipment and machines in our shops, the Chief of Ordnance can redeem his responsibility to supply American soldiers with quality matériel, and economically so. We can talk to our scientific and engineering and industrial counterparts—particularly our contractors—with certainty and understanding. With respect to method, to quality, to reliability, to direction, to ideas, we are able to say "yes" or "no" with assurance.

If we cannot do that, we then let someone else make decisions for us and no longer have control of either quality or costs—we give someone else a blank check.

This is particularly true when we get into the very new, the "wild blue yonder" type of program, such as several we are in now in the missile field. Contractors, whether in research and development or production, are generally proud and competent people. They work better when it is for and with a competent organization staffed with

competent people. (Incidentally, many have told me so.) Our arsenals are in that category.

I HAVE made brief mention of the Ordnance-Industry-Science Team and have given some emphasis to the rôle of the Ordnance Corps in that team effort. I should like to make it perfectly plain that the Ordnance arsenal system, far from being in competition with private industry, provides the leadership which enables that industry to make its finest contribution to the development and production of the materials of war essential to the firepower and mobility of our armed forces. Our responsibilities to American industry and science may be summarized somewhat as follows:

1. To know what Ordnance wants and when it is wanted, and what it does *not* want.

2. To be able to tell industry and science of those wants, basically through design concepts, drawings, and specifications.

3. To confirm progress in supplying those wants through progress reviews, tests or evaluations, and inspections.

4. To provide fair competitive opportunity, commensurate with capability and capacity, to participate in Ordnance programs.

5. To administer all contracts fairly and efficiently.

6. To make available technical guidance and assistance, particularly with information that is available only to the military.

To emphasize the degree of industry and science participation in the Ordnance Corps program, as contrasted with the degree of utilization of our own resources, I should like to cite a few brief facts. The Ordnance Corps will expend, through its arsenal system, approximately $2 billion during fiscal year 1958. Approximately $1.8 billion, or 90 per cent, of that amount will be expended with private industry. I believe these figures speak for themselves and dramatically answer the question, "Do the arsenals compete with private industry?"

Currently, as you know well, there is tremendous emphasis in the rocket, missile, and antimissile missile field. Redstone Arsenal is the pioneer in that field, and the Army Ballistic Missile Agency has done a magnificent job in picking up the Redstone missile and carrying it forward into the Jupiter and related efforts. The commanders of Redstone Arsenal and the Army Ballistic Missile Agency call on the knowledge and skills of the other arsenals for supporting work.

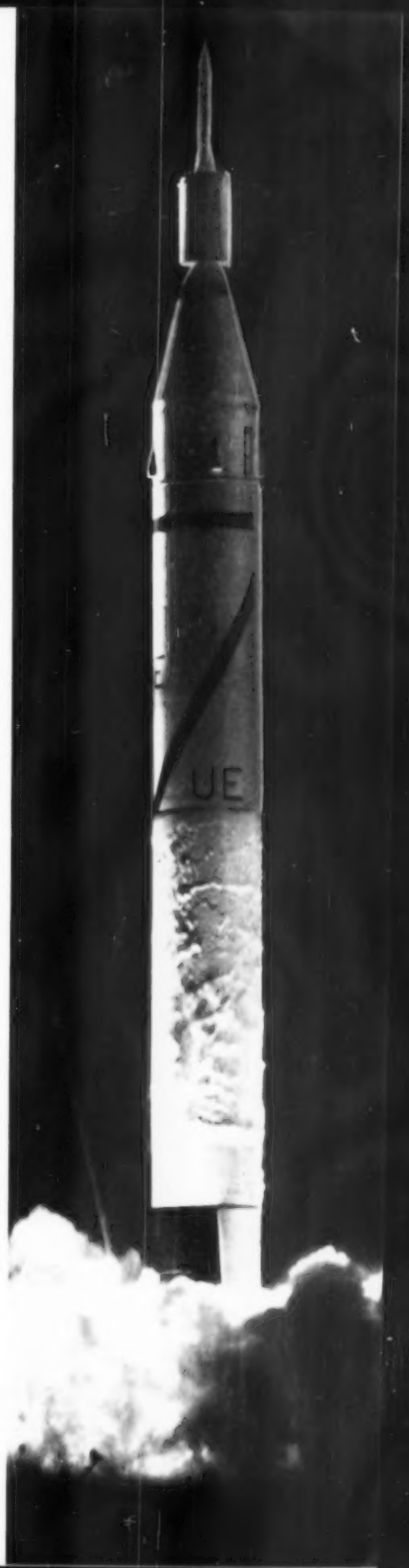
In round dollar figures, this amounted to $150 million in fiscal year 1958, which is about 50 per cent of the total arsenal in-house work load. For instance, Picatinny Arsenal is the Army's center of knowledge in atomics and other special weapons applications. It works for both Redstone and ABMA and in 1958 is at a $24 million level. Rock Island Arsenal will do about $9 million and Watertown Arsenal will do about $8 million in fiscal 1958—both in areas utilizing military knowledge not found anywhere else in the country.

The flexibility of the arsenals with resulting capability to convert to the era of new and improved weapons is well illustrated at Watertown Arsenal. In 1952, 100 per cent of the internal work load at Watertown Arsenal was devoted to heavy field artillery and antiaircraft artillery. Today, nearly 60 per cent of the total in-house effort at Watertown is expended on guided missile and special weapons matériel.

FINALLY, and in summary, I would like to quote from a recent statement of Secretary Brucker:

"The Army must have internal resources of dedicated, talented, and experienced people who can determine what the Army wants . . .

"The existence of the Army-wide arsenal system, wisely supported by Congress over the Army's long history, is another significant aid to our effective use of the public money. Our arsenals are far from manufacturing plants. They are pilot facilities where teams of experts work out production systems and check out manufacturing processes necessary to produce these many complex weapons systems. Our arsenals can closely predict what manufacturing costs ought to be and provide a valuable check on our contractors' bids."



Antisubmarine Warfare

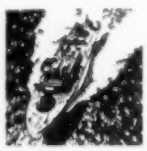
Our means and methods have been improved over those of World War II, but in view of the Soviet's vast undersea fleet much is still to be desired in modern ships, better aircraft, and new detection devices

Vice Adm. Frank R. Watkins

THE primary mission of the United States Navy is to maintain "control of the seas"—that is, to ensure freedom of the seas for peaceful purposes in time of peace and, in time of war, use of the seas for ourselves and our allies while denying that use to the enemy.

This is, in essence, the fundamental purpose of seapower—to make use of the great advantages offered us by the world's oceans such as dispersion, mobility, and deception, all qualities which the U. S. Navy now embodies in its operating forces.

In World War II, our control of the seas permitted us to take the offensive on several fronts simultaneously and to mount sustained land and air operations against the enemy in his own territory, or in territory which he had conquered, far from our own shores. In Korea, control of the seas gave us the ability to throw back Communist aggression at the end of a 7,000-mile logistic pipeline.



Today, with most of the free nations of the world bordering on the oceans and banded together in what amounts to oceanic coalitions, control of the seas by the free world's navies is absolutely vital to mutual defense against the poised Soviet juggernaut.

The United States Navy is the principal part of free-world naval strength.

The Soviets clearly understand this point and, for the past several years, they have been busily building a navy to challenge our control of the seas. They are now the world's second ranking naval power. They have a balanced navy for their needs, including a naval air arm of some 3,000 aircraft.

Admiral Watkins is Commander, Antisubmarine Defense Force, United States Atlantic Fleet, Norfolk, Va.

But by far the most serious threat to our continued control of the seas is the Soviet submarine force. We estimate that they now have more than 450 operational submarines and that at least half of these are modern, postwar designs capable of effective operation far from their home bases. If they are able to arrange for refueling, replenishing, and rearming their submarines at bases in other Communist or collaborating nations, this force could attack free-world shipping throughout the seven seas.

Obviously, the Soviets have designed their submarine force for one purpose: to cut our sea lines of communication so as to isolate us from our allies and forces overseas.

One way to estimate the seriousness of this threat is to compare the Soviet's 450 or more submarines with the relatively small force of 57 submersibles with which Hitler entered World War II.

But this is not an accurate comparison. We are not faced with the possibility of fighting World War II U-boats. Rather, we are faced with the possibility of fighting a vast number of modern submarines which incorporate many postwar improvements such as the snorkel, high submerged speed, and advanced weapons which make them much more dangerous and substantially more difficult to detect and defeat than their World War II predecessors.

OF even greater significance to us in the antisubmarine business are the implications of recent break-throughs in submarine development—the nuclear power plant and the submarine-launched, long-range missile weapon system. With each of these developments, submarine warfare has taken a giant step. The combination of the two, such as we are producing in the Polaris-nuclear submarine weapon system, means that submarines, which have heretofore confined their activities almost entirely to the high seas, will be able to strike targets hundreds of miles from the sea.

As far as we know, the Reds have not matched our progress in these fields, but we are by no means under the delusion that we will maintain for long a monopoly therein. To the contrary, we are convinced that the Communists can, and probably will, take these steps in the near future.

Today there is no known defense against such a weapon system. Once launched, a ballistic missile will travel

inexorably to its target. Obviously, we must be prepared to counter such a threat with correspondingly advanced antisubmarine forces. We must be able to destroy enemy submarines before they can launch their missiles.

The present and future threat of the Soviet submarine force is a matter of grave concern to this country, to the Navy, and particularly to all of us who are responsible for this phase of naval operations.

During the past several years, as intelligence regarding Soviet submarine construction became available, the Navy has instituted appropriate countermeasures.

The terrible destruction of ships and loss of personnel and valuable cargoes in two world wars are too vivid in our memories not to stimulate vigorous attacks on the problems of antisubmarine warfare.

IN general, antisubmarine warfare training has been given new emphasis in the fleets. We know that we will have little or no warning of a future conflict and that, as far as the defense of the United States is concerned, the decisive elements of success may lie in the action we take prior to any declaration of war.

Similarly, we have intensified our search for new weapons and new equipment while improving those that we have. In 1957, the Antisubmarine Defense Force was established in the Atlantic Fleet to coördinate fleet antisubmarine matters. On the staff are a group of highly qualified and experienced officers—including aviators, submariners, and surface ship officers. Every aspect of the antisubmarine-warfare field is being investigated. A close liaison is maintained with the Office of the Chief of Naval Operations, the material bureaus of the Navy Department, the research laboratories, development groups, training schools, and, particularly, the seagoing forces.

The Chief of Naval Operations has established a new office of special coordinator for antisubmarine warfare, a post now held by Rear Adm. Charles E. Weakley.

His mission is to provide the Chief of Naval Operations with special assistance in the planning and direction of all phases of the antisubmarine warfare readiness program. In addition, under his coördination, every bureau, every office, and every laboratory which can contribute to improving the antisubmarine capabilities of the fleet is hard at work in a coördinated effort to accomplish this task.

With regard to fleet operations, there is no doubt that the best way to kill a submarine is to sink it at its home port or alongside its tender before it gets to sea. The atomic strikes at source by the Strategic Air Command and by our carrier strike forces, carefully coordinated in advance and supplemented by our guided-missile submarines and our mining campaign, would be tremendous factors in our eventual success in a showdown with the Soviet submarine force.

Undoubtedly, some submarines would be at sea or would escape this treatment, avoid the mines, and gain the open sea. These submarines would then have to run the gantlet of our own killer submarines which would be on patrol near their harbor entrances and in the transit lanes.

But we must recognize that, with the initiative to open hostilities remaining with the Soviets, they would undoubtedly deploy many submarines covertly in advance, probably many of them near our own coasts, and those submarines must be our early objectives.

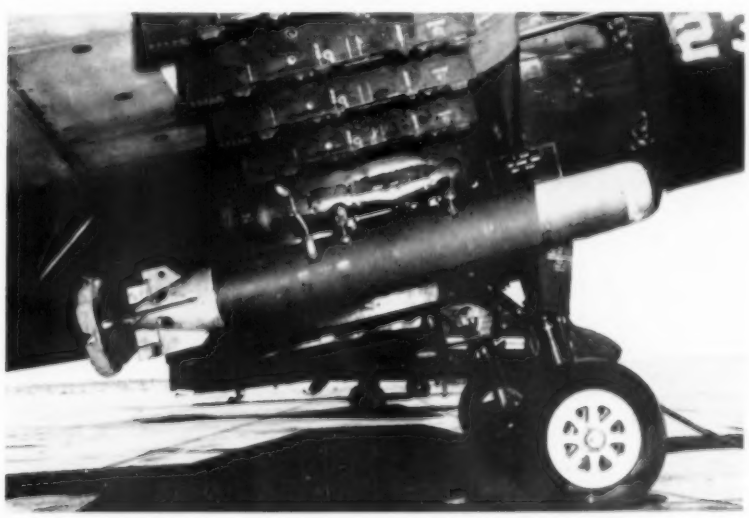
Within the fleet, the full roster of the antisubmarine warfare team includes the antisubmarine carriers, destroyers, fixed-wing carrier aircraft, helicopters, land-based patrol aircraft, seaplanes, blimps, and submarines—both conventional and nuclear-powered.

Each of these ships and aircraft has some special antisubmarine capability. Many of them are highly versatile. Together they form a multiple-threat offensive and defensive team.

Under our present Atlantic Fleet organization, in a period of "alert" or of increased international tension, or at any time the situation indicates, Adm. Jerauld Wright, Commander in Chief, Atlantic Fleet, can assign any part or all of these forces to my command for centralized control.

Among the forces assigned to the commander of the Antisubmarine Defense Force for operational control at all times are the antisubmarine carrier groups. Each of these groups is a coordinated team of surface ships, aircraft, and killer submarines. The particular value of such a team is that it employs the special abilities of each of its members—the long-range detection ability of the submarine, the rapid leapfrog tactics of the helicopter, the speed, area-covering ability, and rapid weapon delivery of the aircraft, and the endurance and punch of the destroyers.

The Mark 43 antisubmarine torpedo homes on its target acoustically (Navy photo).



Just a few months ago, Admiral Wright established within the Atlantic Fleet a special antisubmarine group which we call "Task Group Alfa." This group is under the command of Rear Adm. John S. Thach. It is sort of a "blue ribbon" group, composed of some of our best ships and aircraft squadrons. It specializes in antisubmarine warfare training, improvement of tactics, and in quickly developing tactics for employment of new weapons and equipment reaching the fleet. This group is setting new standards of fleet readiness in antisubmarine warfare.

The Atlantic Fleet also schedules a number of fleet exercises each year. These exercises provide training in many fields, such as escort of convoy operations, which we believe will be necessary in some form in a future war. Other exercises provide experience to our forces in coördinated operations and test out new tactics and new developments under realistic service conditions.

ANTISUBMARINE warfare is a very complex affair. It is, in fact, one of the most complicated types of naval operations. This is due to the nature of the enemy and to the characteristics and natural phenomena of the medium in which he operates, as well as to the complexity of the forces involved at the scene of action.

Each step toward the destruction of an enemy submarine offers special problems, but our most pressing problem is in the area of initial detection. For example, our basic detection device is sonar, which makes use of underwater sound waves much as radar uses radio waves. This device was developed prior to World War II, but it has been substantially improved since 1945.

But detection by sound is hampered by the uncooperative phenomena of sound channels in the sea and by myriad underwater noises and reflections caused by marine life. Out of all these natural sounds we must identify the sounds made by or reflected from an enemy submarine.

Meanwhile, if we can hear the enemy submarine, he probably can hear us, and he proceeds to take either evasive or aggressive action.

There are other detection problems. For instance, radar was used effectively in World War II against submarines. In fact, it spelled the doom of the German submarine force. But radar can detect only a surfaced submarine or, at shorter ranges, a snorkeling submarine, since radar waves do not penetrate water. Radar, therefore, is of little or no value against a nuclear submarine which can remain entirely submerged for many days.

We are working hard on detection and classification devices and techniques. Our scientists are examining a number of interesting new developments in these fields. One or more of them may give us the break-through we require to produce the long-range, positive detection device we need to cope successfully with the nuclear submarine.

In the field of antisubmarine weapons, the picture is much brighter.

The atomic depth charge, which has a very large destructive radius, is now in the fleet. There are also new lightweight homing torpedoes—sort of submersible guided missiles—which can track down and destroy enemy submarines at long ranges. These torpedoes can be launched from ships, fixed-wing aircraft, helicopters, blimps, or submarines.

Our destroyers and frigates have a rocket-propelled depth charge which can be fired quickly in any direction from a trainable mount.

A new rocket-assisted torpedo system (Rat), which delivers a homing torpedo to a point several thousand yards from the launching ship in a matter of seconds, is now being installed in ships of the fleet.

Today, our present antisubmarine forces are effective against modern conventional submarines. We believe that if the showdown came now, we would gain the upper hand, but with current force levels we would take severe losses at sea and suffer damage at home. Under the most favorable circumstances, we do not foresee any such thing as an "airtight" defense against a determined attack in strength.

We have some soft spots. For example, most of our basic antisubmarine ships—the destroyers and destroyer escorts—are of World War II vintage. We have kept them as modern as possible by the installation of new equipment, but they are approaching the end of their useful life. Our shipbuilding program must provide for replacing these ships with modern ones or we shall soon find ourselves in the position of having a large portion of our fleet composed of obsolete ships.

BY the same token, we need more and improved antisubmarine land-based aircraft. We must also continue or accelerate our current program for construction of nuclear killer submarines.

In other words, the development and replacement of our antisubmarine ships, aircraft, weapons, and equipment must keep pace with submarine development.

We need vast improvement in our detection equipment. We must be able to detect submarines at long range and to destroy them at long range before they can launch their torpedoes or guided missiles.

We cannot again afford to engage in a war of attrition wherein we exchange cities, industrial complexes, and military bases for enemy submarines, as we exchanged ships for submarines in the last two world wars.

Many of our scientists, engineers, and technicians, both in government and in private industry, are working on these urgent antisubmarine problems. I have great confidence in their ability to find the answers if they receive the support they need.

Finally, the antisubmarine warfare business is expensive. We see no neat package solution to the problem at the present time. If we have a showdown with the Soviet submarines, in either a limited-war situation or as part of a general war, it will be an all-hands, all-Navy effort.

To be prepared to defeat this attack will cost a great deal of money, and this money cannot be provided at the expense of the many other urgent requirements of the armed forces.

But the cost will not be too high a price to pay for continued control of the seas.

Marines in the Making

The Corps remains convinced that while modern weapons and techniques are important in this age of guided missiles and nuclear power, its most valuable asset is the loyal courage of the individual Marine

Maj. Gen. W. M. Greene, Jr.

THE United States Marine Corps has been in business for over 182 years. Like any other going concern, it has had to keep up with the times.

As an example, following World War I the Marine Corps made an exhaustive study of the amphibious campaign for the Dardanelles and commenced the development with the U. S. Navy of new amphibious techniques and equipments. When World War II came along, these methods and machinery served as the basis for the successful amphibious campaigns conducted in the Pacific, the Atlantic, and the Mediterranean.

The first atomic bomb had scarcely fallen on Hiroshima when the Marine Corps initiated a detailed examination of its World War II tactical doctrine, and, as a direct result, experiments with the helicopter were intensified. The campaign in Korea definitely proved the value of the helicopter as a military vehicle, and today the Marine Corps' new tactical doctrine of vertical envelopment is built around this equipment.

Since World War II, the Marine Corps has continuously monitored new developments in the field of ordnance and armament. It is measuring the impact of these developments on organization, tactics, and techniques, and, as a result, our Marine divisions are now undergoing major reorganization. Our combat units have been trained in dispersed tactics; we are pushing the technique of vertical envelopment by helicopter; we are acquiring new equipment such as the Ontos self-propelled rocket launcher, the Terrier guided missile, the Mighty Mite vehicle, and the Sidewinder air-to-air missile.

General Greene is Assistant Chief of Staff for Operations, United States Marine Corps, Washington, D. C.

All of these are important. But more important is the individual Marine who will use this equipment, for it is the individual Marine and his training that constitute the most important trade secret of our Corps.

During our business life we have managed to keep on top of new developments in our field, but above all we have attached a Jesuitlike importance to the training of the individual who joins our ranks. That is why we have the longest, toughest, and most exacting basic training period of any of the military services. That is why we tell a recruit, "You have no right to be a Marine; you must first prove yourself worthy of being one."

Certainly we teach the importance of equipment, but first and foremost we teach things of the spirit. This was the strength behind the Marine cutlass in the boarding parties of the fighting days of sail. It was this same spirit that enabled the Marines of the 1st Division to fight their way through the bitter cold and snow-covered mountains of Korea to the sea—and to bring out their dead and wounded with them. This is the meaning behind our saying, "Once a Marine—always a Marine."

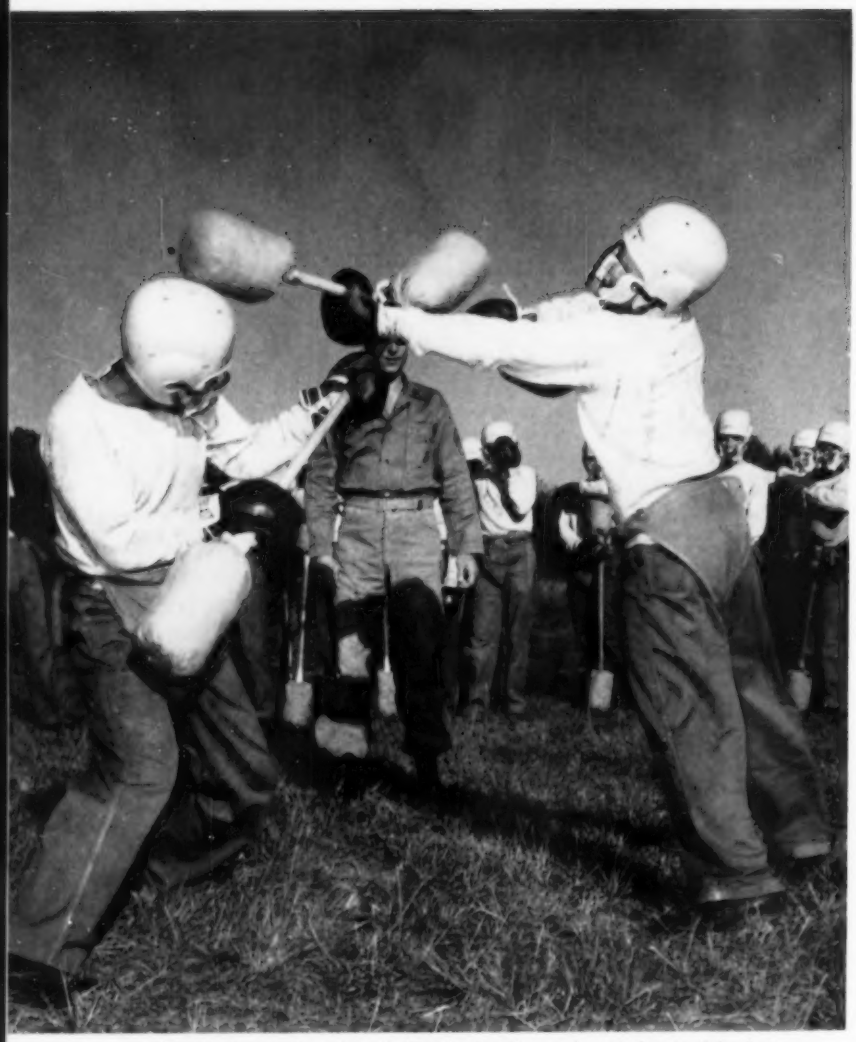
It is still heart, not hardware, which comes first. It seems to me that in these days we have almost forgotten this. We are not going to be able to buy victory—our sons must earn it.

OUR sons live in the golden age of the American teenager. As a result, the Marine Corps is faced with the tremendous problem of maintaining quality control—of developing from the present-day American boy a man capable and worthy of carrying on our great traditions—of producing a Roman soldier while Rome burns.

Are we able to do this? Our recruiting posters say we can.

Twenty-eight years ago when I entered the Marine Corps, the typical Marine was a settled, mature individual. He was a volunteer who had entered the Corps for adventure, travel, and excitement. He intended to make the Corps a career.

What about today's Marine? During a recent 12-month period we processed some 27,000 recruits through our depot at Parris Island. I personally supervised the flow of this human material through our training plant, and I feel that I can report the real facts about our principal trade secret—the individ-



Using the newly adopted "Pugil stick," recruits at Parris Island get practice and instruction in close-combat training (Marine Corps photo).

ual Marine and the way he is being trained.

The typical recruit is 18 years old. He is a volunteer. He comes from every corner of the United States. He represents every strata of our society. He may be black or white, yellow or brown. Remember, I said that he was 18 years old. He is a typical American teenager and—whether you are a parent or not—I am sure that you have an understanding of what that means!

The recruit arrives at Parris Island with all his teenage problems. What are these problems? Physically, he is not in good shape. He has had enough to eat but not a balanced diet. He has been smoking too much. He has been riding or sitting most of the time.

Mentally, he feels insecure. His home has been principally a roof. His school has not presented him with an intellectual challenge or succeeded in teaching him much about the tap roots of his country. His church has not satisfied his hidden hunger for religion. Secretly, he wants to belong to something good, strong, challenging, secure, and emotionally satisfying.

For the first time in his life he really feels on his own. Privately, he is worried about his ability to make the grade at Parris Island. He is not interested primarily in his pay, educational opportunities, or learning a trade. He does not know whether or not he wants to make the Marine Corps a career. He is looking for color, adventure, and a chance to prove himself. He also may want to discharge his military obligation before the draft gets him.

This is the type of raw material which arrives at our training plant today. As you can see, it is in many ways different material from that of thirty years ago, and we have had to change some of our production methods in order to maintain our traditional quality control.

IN general, we have increased our emphasis on the teaching of loyalty, patriotism, instant obedience to orders, self-discipline, the strength of religious belief, the importance of complete and thorough knowledge of weapons, and how to take care of one's self and one's buddies. This is the broad picture. Now, let's get down to brass tacks and look at a few details.

We have increased our basic training to a total of sixteen weeks. Twelve of these are spent at the recruit depot, Parris Island, and four more at Camp Lejeune. This is the longest basic training time of any of the services. In addition, we give our six months' Reserve trainees an additional thirty days of advanced combat training.

We have established the most effective large-scale physical-training program in this country. Recently, Shane MacCarthy, the President's Special Assistant on Youth Fitness, visited Parris Island to see that program in operation. He came away saying: "The Marine Corps has the most unique program in this country. I am convinced after what I have seen here that I would like to have each of my five sons get this kind of education."

Every boy who arrives at Parris Island is not only given a complete physical, mental, and psychiatric examination, he also is given a battery of strength tests to determine accurately his muscular capability. He cannot go on schedule until he is able to pass the minimum requirement.

During his three months of training, he is reëxamined in order to determine exactly what progress he is making in building up his body. If he is too weak, thin, or underweight, he is assigned to a special training company where he goes on a diet and exercises until he is

physically strong enough to commence regular training.

The physical-training program is built around a daily schedule of calisthenics and rough body contact games, such as judo, pushball, soccer, and bayonet fighting.

The results are startling and show what can be done in a relatively short time with underdeveloped but good stock—the American boy.

When we set up this program, our goal was to develop an individual with physical strength and mental self-confidence. To our surprise, we gained something equally important. We discovered that within forty-eight hours after a teenage boy starts on this schedule, a tremendous well of enthusiasm is unlocked within him—enthusiasm which flows over into everything else that he does from marksmanship to marking clothes. This has proved to be the most powerful psychological lever in our program.

I believe the same beneficial result could be gained in our public school system if this particular method of group physical training were to be adopted and made compulsory for all boys.

A limited number of boys arrived at Parris Island unable to read or write satisfactorily. These men are not discarded by the Marine Corps. Every effort is made to salvage them through a special school for slow learners. Those who graduate from this school enter regular training and usually turn out to be good Marines. Many of them become small-unit leaders. They also become better citizens.

THE biggest problem we have to face today in processing of material is that of discipline—the unruly attitude of the American teenager which typifies the popular character known as the juvenile delinquent. This type arrives at Parris Island in the paradoxical position of a volunteer, yet an unwilling entrant into a system which calls for instant obedience and loyalty.

We have learned how to cope successfully with this type of boy. At the first indication of noncoöperation on his part we withdraw him immediately from his platoon, from his accustomed environment, and from association with his buddies and move him to a motivation platoon. Here he sits down with an experienced Marine captain who discusses his problem with him. If necessary, we add a psychiatrist to the group to help in the analysis.

Invariably, we find that the boy really wants to be a Marine but that he has either established an attitude before his platoon and instructors which he feels he has to defend, or else he has a personal problem such as physical weakness which he tries to cover up by a show of noncoöperation.

Once we have spotted his trouble, we can help him. Where his community has failed, we can succeed because we are able to change his environment completely and immediately so that he can make a fresh start. Well over ninety per cent of these disciplinary cases are returned to training and graduate.

I am convinced that our national disquiet about our seeming inability to cope with juvenile delinquency is exaggerated. Marine Corps recruit training disproves that fear.

Every American boy wants to be a leader; furthermore, he likes to play on a team. We exploit these desires. Throughout his sixteen weeks of training, the recruit is made to feel that he is an important member of a small 4-man group called the fire team. This group has the same basic appeal to a boy as does a basketball team. All members of this team are buddies, and each man is given the opportunity to be leader of his team. Attitudes of patriotism, loyalty, courage, and efficiency are developed within the focus of this small group. It is here that combat leaders are made.

These fighting teams, carried over as they are to making infantry units, are the real secret of our success in battle.

The Marine Corps remains convinced that today, in this world of guided missiles and nuclear power, its most important asset is the individual Marine.

The recruit who comes to our training plant today in many ways is different from the recruit of thirty years ago, but we have found him to be of the same sound material. We have adjusted our manufacturing process and are maintaining the traditional high quality control of our product.

The Marine of today is just as good as and in some ways better than his father or grandfather, and he is just as ready and capable of fighting for his country as he was in 1775 or in 1942.

A unique drill with a 400-pound "log" of canvas-covered pipe teaches recruits the value of teamwork and promotes physical conditioning (Marine Corps photo).

Aircraft Instrumentation

With our supersonic aircraft becoming more complex and the task of our pilots more demanding, it is necessary that the cockpit instruments keep pace and even be ready for future weapon systems

Maj. Gen. M. C. Demler

COCKPIT instrument problems were nonexistent in early military aircraft—there were no cockpit instruments, period. When necessity dictated their use, the relatively few instruments then used were mounted in any convenient location.

Let's take the P-2, for instance. This airplane featured a few cockpit instruments, but they hardly could be associated with the term "instrument panel."

In those days, aircraft instruments were used only as auxiliary and not as active flight references. Actual flight references were the seat of the pants, the wind in the rigging, the horizon, and the control back-pressure.

When flight by reference to instruments became possible, the instrument panel became important and so did the arrangement of instruments on the panel. The early pioneer "instrument board" was a tremendous improvement over the cockpit of the P-2.

By World War II it had become necessary for military aircraft to have an instrument panel which permitted extensive all-weather flying. The standardized arrangement of six basic flight instruments generally became known as the "sacred six." When instrument approach systems became a reality, the cross-pointer indicator was added, and the addition of the radio-magnetic indicator resulted in the "basic eight" configuration.

The combination is representative of most aircraft flying today. For specialized phases of military missions, flown in accordance with a computing system aboard an aircraft, additional instruments must be added to these "basic eight," as must instruments for operation of the propulsion system and auxiliary devices.

General Demler is Deputy Commander for Research and Development, United States Air Force, Washington, D. C.

In aircraft now in advanced stages of development, the pilot's task has been considerably expanded. He must operate the aircraft over greatly increased performance profiles to do what complex subsystems command. He must operate some subsystems directly while flying the aircraft.

Even the problem of communication, formerly a simple task of operating a radio, has become a multichannel operation of relative complexity, which the pilot must operate often while flying completely on instruments. For new aircraft under development, his task will be much more exacting than for any aircraft now in active service.

Since World War II, a virtual revolution in the development of aircraft as air weapons has taken place in both the increased performance of the vehicle and its expanded scope as a weapon of war. To the dynamics of the technical problems involved there also has been added a dominant new problem—the dynamics of the production line.

To meet the challenge of these problems, the Air Force organized the Air Research and Development Command, and developed its now famous weapon-system concept. This concept represented a major but necessary change in the development and production of the modern air weapon, a change which pulled the many related aspects together as a system and treated the entire process in a systematic way. The concept evolved as we gained experience with it, and now it has become a "way of life" for our future air weapon development.

BUT as development of new generations of aircraft proceeded, cockpits suddenly became crowded. The instrument panels were especially bad. We wanted standardization across the board as much as possible between weapon-system cockpits. To this end we had intentionally omitted the instrument panel from the integration process of the weapon-system concept to avoid special-purpose panels for each weapon system. Our pilot training system and flight safety considerations demanded it, but our instrument development process simply wasn't organized to cope with the situation we now faced.

There arose myriad new requirements for new displays on the pilot's panel. Each subsystem was being developed complete with its own instruments for the pilot to see—that is, if

space could be found in the cockpit for them. Instruments were not generally available that could display the same parameters for different phases of the mission. Some that were available were engineering triumphs but operational failures—the mechanism worked but the pilot couldn't fly by it.

We realized that we had to do something to correct this highly unsatisfactory situation. We could not possibly allow development of special-purpose individual panels for each new weapon system, a solution we had adopted for many other items of equipment. Yet, if a satisfactory degree of standardization were to be maintained between weapon systems without compromising mission capability, it was clear that some major changes would have to be made in our organization and methods.

After thorough study and some preliminary reorganization, organizational elements and individuals directly concerned with the development of flight control instruments, equipment, and systems were regrouped and established as the Flight Control Laboratory at the Wright Air Develepoment Center, providing the management structure for centrally guided research and development in this critical field.

In organizing the Air Force instrument development program, which was undertaken immediately after formation of this new laboratory, it was mandatory that certain fundamental requirements be met. Specifically, there are four vital requirements that must be satisfied by the program.

FIRST, the program must be geared into the weapon-system concept as developed and practiced by the Air Force. Otherwise, due to the long lead times of weapon-system development and the dynamics of the production line, the program output simply will not be used. We will be continuously solving yesterday's problem.

Secondly, the program must be centered in the Air Force. Specific studies, investigations, and developments will be contracted to qualified industry. However, the continuous orientation of the program to the requirements of the Air Force, and the continuous compromises made between considerations of human factors, standardization, training, logistics, producibility, maintainability, reliability, and application to a variety of weapon systems can only be accomplished by active Air Force management.

These factors dictate the location of the program management at the seat of ARDC's weapon system management —the Wright Air Development Center.

Thirdly, the program must embrace *all* forms of instrument development sponsored by the Air Force in a practical, realizable form. In addition to the development for standardization of individual instruments, we have instruments being developed along with particular subsystems, such as bombing or reconnaissance systems, for example, in both experimental versions and operational development for particular weapons.

We also have developed some instruments as part of particular aircraft development programs. Then there is an area where each of the research and development laboratories in any way concerned with any instruments, sponsors general research and development on methods, techniques, and so forth, related to display and mechanization.

The fourth fundamental requirement of the program is to focus proper attention within the Air Force on funding and mangement problems so that we can allocate the required amount of the funds that we have to work with to get the really important things done, and in time to use them.

The program necessarily must be based upon inputs of all of the laboratories concerned in any way with cockpit instruments. Accordingly, a working group was established with representatives from each such laboratory, chairmanned by the Flight Control Laboratory.

A single new project, "Project 6190," was initiated to include all state-of-the-art work by any of the laboratories that were not specifically covered under other developmental projects. The working group plans the total effort that should be sponsored to advance the state of the art of instrument display. It considers *all*, in being, to plan *additional* efforts required to achieve a balanced program.

THE organization of this program effort was completed in January 1955. Project 6190 was initiated in March 1955. During that year, seventeen major tasks and forty-eight subtasks were initiated under this project. Since then there has been unprecedented creative activity in the areas embraced by the program, and I can report that the entire program as a whole is working exceptionally well.

The cockpit of an early P-2 featured a few instruments for auxiliary reference.

One of the accomplishments of the program is the catalytic action which has been provided to many areas of the related industry. This has been achieved through innumerable individual and group contacts, as well as specific symposia for particular subjects. An example of the latter was a symposium on "Psychological Aspects of Cockpit Design" sponsored in October 1956 by the Aeromedical Laboratory.

WE want to get everyone working on the right problem—to control the direction of effort without stifling creativity. To achieve this end we have deliberately not sought general publicity for the program but concentrated upon such selective groups and occasions as have a real meaning to the program effort.

Another achievement is the development of new concepts in cockpit instruments. One of these is what we call "whole-panel" instrumentation. Let me illustrate this concept by describing four new instruments that are products of the program.

As a consequence of continued development, the "basic eight" were improved. Each of these instruments was developed, in general, without much consideration of the information to be shown on other instruments to be used with it or the type of display to be used on these instruments.

The new developmental weapon systems require some specific new display capabilities. In addition to performance areas outside the limits of these instruments, we need to show "command" values—that is, what the pilot should do in addition to what his present situation is. We need to show "command" altitude, "command" Mach, and "command" heading in addition to some entirely new factors such as target altitude. Clearly, we couldn't show these parameters on this type of instrument. We needed a new synthesis.

We began with our best flight-proven attitude indicator in a five-inch case size and added perspective lines below the horizon. The lines we formerly had used above the horizon to give good bank reference at high pitch angles were removed. Instead of these, a small wire, painted alternately black and white, was added to the roll gimbal thus providing constant and precise bank reference at high pitch angles without clutter.

We added a vertical needle which serves as a flight director as well as to command the pilot to turn when following commanded headings, for holding straight on instrument takeoffs, and so forth. In any mission mode requiring lateral steering, this needle may be used to direct the pilot. When not in actual use, it retracts out of view.

An arrow can show pitch commands and indicate glide slope displacement when making an instrument approach. This indicator, when used with an appropriate gyro reference, gives full, consistent, all-attitude indication to the pilot with no "flip-overs" or otherwise unnatural instrument indications.

When the pilot moves his control stick fore and aft, he not only controls pitch but several other parameters by the same control action: airspeed, altitude, rate of climb, angle of attack, and normal acceleration. On a constant-Mach flight, the desired Mach number is also held by pitch control.

Significant increases in speed and altitude capability have made it extremely difficult to show the increased range of these parameters while still retaining good readability. The additional necessity of showing the "command" values, which I mentioned before, made it necessary to depart from our traditional round configuration for these instruments.

By adopting a rectangular form, and using moving tapes read against a fixed-center reference line, we could meet these otherwise conflicting requirements, and we could add something by the arrangement of such instruments that was not present in the individual units alone.

For the moment, let's consider only the rectangular instrument on the right side of the attitude indicator. This instrument shows rate of climb, altitude, and an altitude-planning scale. The center scale shows altitude on a moving tape, read at the center reference marks.

For reference, let us use an altitude of 30,000 feet. "Command" altitude is recorded by the moving bar across the altitude tape. The "command" altitude for example, let us say, is above the present altitude. To reach it, the pilot should react quite naturally by pulling back on the control stick. When he is flying at the "commanded" altitude, the "command" bar will be at the center reference marks, coinciding with the "actual" altitude indication.

The scale next to the attitude indicator shows rate of climb or descent by a sensitive moving pointer for the first 2,000 feet per minute. After this value is reached, the pointer is stationary at either the upper or lower window, and a moving tape behind the window indicates the actual rate in the window, over the full performance range.

The scale on the right is a planning scale where the actual altitude is repeated by a thermometerlike tape. "Command" altitude is repeated by the small bar; "target" altitude is shown by the square symbol; and cabin pressure altitude is shown by a dashed symbol on the right, indicating 12,000 feet in this particular case (see photo on page 221).

IN addition to these parameters, a planning scale shows the entire altitude picture at a glance, though in considerably reduced scale, and can serve as a stand-by or emergency source of altitude indication.

Now consider the instrument on the left side of the attitude indicator. It shows Mach number on the left scale, which is also a moving tape. Present Mach is read at the center reference marks. The numbers increase downward from the center reference. This keeps the sensing the same as that used in the altimeter—moving the control stick forward will increase the Mach number. Thus the *control action* required to follow the "command" Mach indicator is identical with that required to follow the "command" altitude indicator. A "limit Mach" bar also is provided.

The middle scale of the left instrument shows indicated airspeed in the same manner.

The scale next to the attitude indicator shows "maneuver limit" due to either angle of attack or normal accel-

eration. The "clear" area above the center reference mark is an indication of this margin for maneuver. The cross-hatched tape moves down to reach this line at the stall angle of attack, while the shutter moves down with increasing acceleration, reaching the center line at the limit allowed.

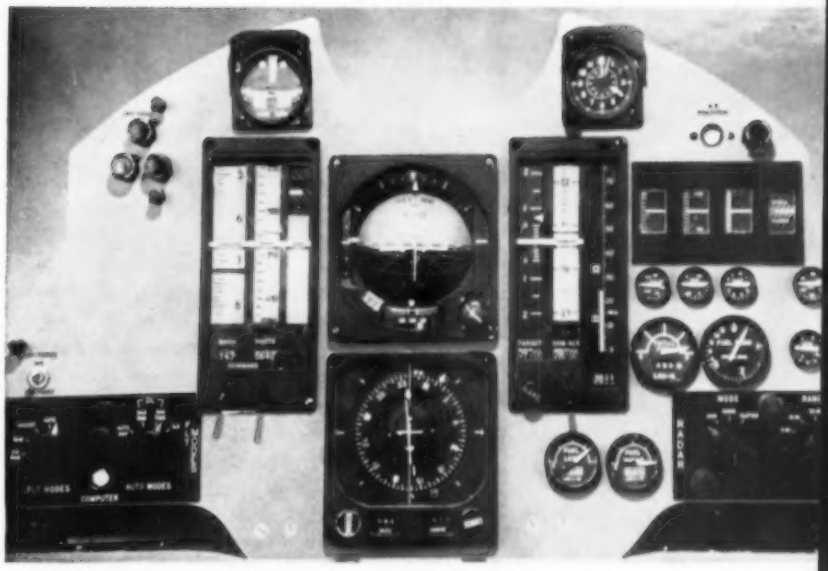
THIS concept thus provides a consistent frame of reference, starting with the fixed aircraft symbol and extending its wings along the center reference line. Actual values of speed and altitude are always read at the same place, and may be shown to the desired degree of readability over any performance range required simply by making the tapes long enough. Yet the frontal area of the instruments may be kept to reasonable size.

Even more important in accomplishing the mission, it is not necessary to read *any* numbers—the "command" markers require only the appropriate control action to keep them in the center, with the reference line unbroken. They indicate at a glance the required action in a natural way. Slewing switches permit the pilot to use the "command" markers manually, as desired, whenever such indication is not provided automatically.

Now, let us consider the bottom instrument. It is a "horizontal situation indicator" showing heading by a stabilized card, which therefore rotates with respect to the case. As in the attitude indicator, the little aircraft symbol in the center of the instrument does not move. It points to the top of the card, where, at the reference mark, the aircraft's actual heading is always shown.

A "COMMAND" heading marker is provided which coincides with the "actual" heading. An outer bearing pointer is provided in the shape of a large arrowhead. Function windows indicate the particular mode being used ("Omni"). A distance read-out appears at the lower left. A "selected-course" knob and window are provided at the lower right. This now positions the course bar located on the rotating card.

Four new instruments present a simple but very effective picture to the pilot. The attitude indicator and the horizontal situation indicator show only what is necessary, but their versatility extends to a very wide variety of missions. The two side instruments have practically unlimited growth potential, as far as aircraft performance is concerned, with little or no change in what the pilot sees. "Command" indicators are provided to cover all that it is possible to command the pilot to do. Thus the system applies to greatly different weapon systems.



Mock-up of a new flight group of instruments for today's complex aircraft.

Another achievement of the program may also be illustrated by these same four instruments. We have successfully accelerated instrument development and produced flyable equipment in an unprecedentedly short time.

In one instance we had a T-33 in the air less than a year from the date of our development contracts for panel instruments. This aircraft began flight tests at WADC in September 1956, and by December 1957 we had accumulated approximately 300 hours.

The results of flight test of this panel gave us definite proof of the panel's feasibility and confirmed its basic design features, such as the sensing, the direction of numbers on the tapes, and so forth.

From a long-range point of view, perhaps the most important of our program achievements is that we have geared it to our weapon-system development. This requires a very early start, for although it is sometimes possible to catch an aircraft development "on the run," so to speak, the only way that any really effective results can be obtained is by starting with a mission analysis in the preliminary design stage before the conveyor belt of the production line starts to turn.

IT is only too painfully evident from the number of relatively new aircraft that are flying today with instruments that are far behind the research and development state of the art that the output of any successful program must get into aircraft *before* they come off that belt.

We start now with a specific work statement in the initial weapon system contract. When it is determined what new displays must be provided, in addition to those on hand or being developed for another weapon system, these are developed and in time to be satisfactorily flight-tested by the Air Force prior to being installed in aircraft for which developed.

This is in addition to the complete operational suitability tests to be performed on some of the earliest complete weapon systems that come off the line. The earlier test is in the nature of a flight safety test and is mandatory for all primary pilot-panel instruments.

We have learned over and over again, in very painful lessons, that many ap-

parently good ideas simply don't work out in the air.

The central program guidance rests on the broad base indicated between many contributing sources of useful information and development. This central guidance is provided within WADC by the Flight Control Laboratory, which has been given approval authority over all new displays for the pilot's, copilot's, and engineer's panels.

WITHOUT such central approval authority, there never could be a "whole-panel" development. We would be like a number of artists all trying simultaneously to paint a picture on the same canvas.

Another important aspect of this task is to use all creative talent effectively. We have to stop people from coming in and, in essence, saying, "Here is a solution. Surely you have a problem to fit it." We have to interest these people in working on the problems that need to be solved. We have to indicate continuously what these problems are.

Many people have an entirely erroneous notion of what constitutes an "important" display problem upon which work should be done. It is not simply a determination that without display of a given parameter the mission capability would be impaired. This is a necessary but totally insufficient condition.

What is vital is the judgment of the deficiency of known methods of displaying the parameter in question, and, even further, judgment of this deficiency against other deficiencies. We won't enhance our total capability by perfecting a few links in the chain while others are neglected.

To summarize, the following are six general principles of orientation that are essential to the program's success:

1. It must be *product-oriented*, not tool- or technique- or method-oriented —evolutionary, not revolutionary. We must be able to live with the results; for instance, they must be practical in regards to training. We must make the maximum use of our accumulated pilot experience, with a minimum of mental "erasing" required.

2. We have no "ultimate" goal. Indeed, we are positively convinced that there can be no such thing unless we refer to a static technology. An "ultimate" solution for any vehicle would look ludicrous in the developments which will replace it in very few years —often in the lead time required for such an "ultimate."

At best, no "ultimate" can be an ultimate very long, and it seems inevitable that contemplation of the ultimate could only restrict the continuous alertness and seeking process so vital to creative technology.

Rather, this program is a continuous, vigorous, aggressive one. It has no "interims" and no "by-products." It aims for practical, usable results from design objectives, not fortuitous accidents.

3. Our objective is to optimize *weapons*, not the man and the machine. The latter balance must be attained as a subsidiary objective to the military effectiveness of the weapon system. We don't even necessarily want the solution which is "easiest" for the pilot—we want one he can use effectively with complete reliability.

We don't want blind automation or unnecessary computation. The man is in the piloted aircraft for a purpose, and we should use him effectively, making piloted aircraft an intelligent complement to missile forces, not just a piloted missile.

4. The term "whole panel" as we use it refers to design philosophy for units of the panel and to the conveying of intelligence by the completed panel, not to its literal construction. We want a mosaic, not a mural.

WE need the building-block concept to be able to adapt to a variety of panel shapes, sizes, and clearance availability of many cockpits. This concept also gives much greater reliability and is easier from a logistic point of view.

It is also much more flexible, allowing us to take continuous advantage of the changing state of the art and to cope with changing requirements.

5. Reasonable standardization must be had in this crucial area of the cockpit but must not be a stumbling block. We must meet fully the requirements of the military mission, but we do not want special-purpose systems in different aircraft. Our building-block concept, together with the other provisions of our program, allows this. We want the smallest number of "families" of such blocks consistent with full mission accomplishment. Therefore we favor those display methods that allow the most growth potential to cope with higher performance areas.

6. We must "fly before we buy." Though we use every tool in our kit to assure that the finished product will be acceptable, it has been demonstrated repeatedly that the only proof in this business is an actual successful flight test.

WHAT about the future? We are rapidly moving into the space age. The Air Force mission here is especially challenging, and we are already working on a number of new problems.

For instance, experiments are being conducted by the Aeromedical Laboratory at WADC to determine the problems of long-term occupation of a small cabin by a multimember crew. One of these which was recently completed indicated that five men can function satisfactorily for a period of at least five days, and probably much longer, in a relatively confined space and with a rather heavy work schedule.

The space age brings into being a whole list of problems. We must be careful not to oversimplify them and inadvertently mask the critical aspects. We must first learn *what* to display, then *how* to display it intelligently. Noteworthy and obvious problems are energy trade-offs and related dynamic parameters as manned flight above the "static ceilings" becomes reality.

In the space age we obviously don't want some analogs that might occur to an observer on the earth's surface. Attitude, for example, will have to be with reference to the flight path, at least during a crucial part of the mission, not with respect to the earth's surface. The pilot, though "in contact," must fly entirely "on instruments"—he cannot possibly judge what action to take from direct observation.

One problem will be even more severe—time. All creative talent must be at work on the right problems. Therefore, the central guidance responsibility of the program will be even more important to the Air Force if it is to achieve its fullest mission capability.

Men in the Missile Age

Just as the advent of military aircraft called for men with unique physical and mental qualifications, so modern missiles and space vehicles will demand the development of a new breed of servicemen

Lieut. Gen. Ira C. Eaker

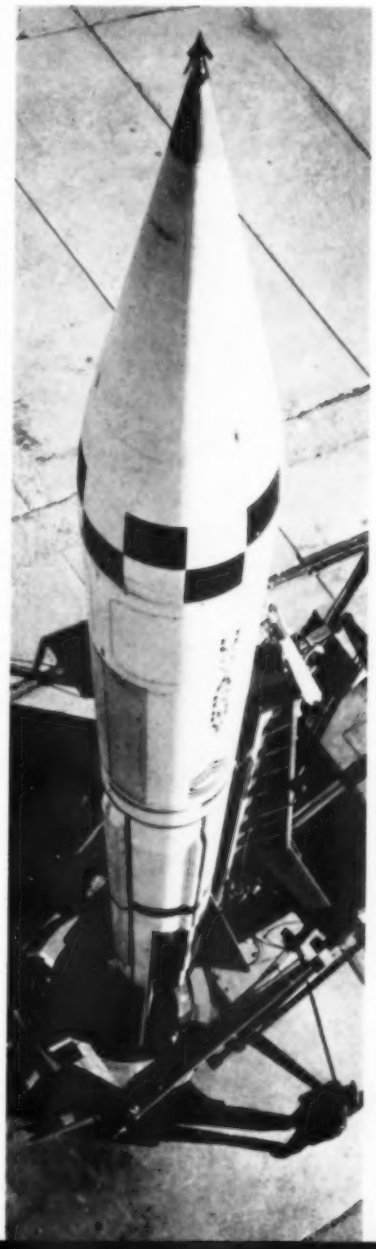
THIRTEEN years ago, at the end of World War II, there were no missiles in our military arsenals, and therefore no missilemen.

In little more than a decade we have witnessed a radical change. This year nearly a third as much defense money is devoted to missile systems as to aircraft, and the ratio in favor of missiles is rising rapidly. If the present trend continues, within two or three years our missile procurement may equal the procurement of aircraft for the military services.

The significance of this change goes deeper than the fact that we now have more than twenty types of weapons bearing the label "missile"—ICBM's, IRBM's, battlefield missiles, submarine-launched missiles, aircraft-launched missiles, and antiaircraft missiles. Of at least equal importance are the new human requirements of the missile age.

For the selection of missilemen we must develop new criteria for physical fitness, education, native intelligence, and emotional stability. We must even begin to think in terms of a new kind of courage.

This human side of the missile story has been largely ignored in the press and by congressional investigations concerned with weapons and space exploration. Most interest has centered around the vehicles themselves. Perhaps it is time to take a look at the kinds of people involved: the producers, the maintenance men, and the new-type warriors we shall need.



Already hundreds of thousands of Americans are engaged in some form of activity in connection with missiles. They break down generally into three main categories: those who design and manufacture missiles; those who man, maintain, and launch missiles; and, finally, those who direct missile operations—the commanders.

FIRST, some thoughts about the missile makers. The initial interest in missiles grew primarily from the German effort in the last war when the V-1 and later the V-2 caused near panic and occasioned a tremendous military defensive effort from the British Isles.

At the close of the war when our commanders and scientists had a look at the German laboratories, launching sites, and tactical and strategic plans, and, more particularly, when they could talk to the German scientists, engineers, and technicians who had devised and launched these new weapons, our military and political leaders acknowledged a new and significant addition to the weapons list.

As always happens, the aftermath of war found us destroying our military organizations, closing our munitions factories, dismantling our weapons laboratories, and rushing back to peaceful pursuits, apparently on the mistaken theory that the war was over and that there was little further need for armies or navies or air forces—or for research and development looking toward new weapons for the future.

In a short while the belligerent attitude of Russia gave us a rude awakening, and we belatedly set about repairing the havoc of demobilization. One of the features of this activity involved a recognition of the need for research and development, and some long-overdue planning in what the war of the future would be and what the requirements of national security in the years ahead would demand.

It was at this time that all three of our services began to devote considerable study and some of their very limited research and development funds to missiles. When break-throughs in the atomic energy field made available nuclear warheads for missiles, plans were made and activity started to produce ICBM's, IRBM's, and even battlefield missiles, on high priority.

The so-called rivalry, more fairly described as competition between the services, to have the first and the best of the missiles in the war chest, led the services to rush to the aircraft industry and to the young electronics industry with missile orders. In quick response industry began to recruit from the universities and to reorient from their own laboratories groups of scientists, engineers, and technicians for missile design, development, and manufacture.

IT was soon evident that we had available in this country a very limited group of qualified scientists and technicians for this task. It also became apparent that we had been very remiss in allowing the Russians to capture so many of the German scientists responsible for the V-1 and V-2.

Probably the most significant development in weapons manufacture in the last five or six years has been the feverish activity of the weapons-making industry to build up its laboratories for missile research and to assemble and train scientists and technicians to provide leadership in this area.

As a people and as a nation we made some understandable mistakes. We scattered our scientific effort into too many laboratories and plants, and we undertook the development of so many types of missiles that we did not accomplish the desired result in the fashion and with the speed and success that we had achieved, by concentration, in developing the A-bomb.

General Eaker (U.S.A.F., Ret.) has a long and distinguished career in military aviation. A pioneer in the Army Air Corps, he climaxed his outstanding record as commander of the Eighth Air Force in Europe and later as Commander in Chief, Mediterranean Allied Air Forces, in the Second World War. In 1945 he became Chief of Staff, A.A.F.

In addition to his professional leadership, his facile pen, as is evident in this article, has merited for him added distinction. He is presently a vice-president of Douglas Aircraft Company with offices in Washington, D. C.

We found also, to the surprise of many and the dismay of some of our people, that the educational system in our schools was not conducive to the production of scientists and technicians needed in the missile era in the numbers required. This discovery led to some recrimination last October when the Russians launched Sputnik I.

Thanks to the Russians, very serious scrutiny and consideration are being given to the overhaul of our educational system, so that we can produce in the future the requisite number of missile designers and makers. It is to be hoped that we will pursue this objective diligently until we can be assured that we always will have enough scientific and technical talent to give us missiles and space vehicles, equal at least, and let us hope superior, to those available to any hostile nation. This can well be one of the prime elements in our survival as free people.

But merely having a sufficiency of scientific and technical personnel is not enough. We must keep intact and active the structures in which they work, where they are so motivated that their genius may flower.

If we are to attain and maintain an adequate missile-producing capacity we must, by wise government planning, make sure that the industrial base of our missile power is not threatened with extinction by the kind of stop-and-go, feast-and-famine financial programming that has been a nightmare for the aircraft industry for too long.

Similarly, we must ensure a sound and stable program of research and development in missiles, satellites, and space vehicles.

IF we fail in these respects there is only one hope left: that the Russians will save us from our own foolishness, as they have in the past, by a new hostile gesture, some gross cruelty, or a startling scientific achievement like Sputnik.

In any consideration of people in the missile age, those who man, maintain, and launch missiles and space vehicles must always be of prime concern. The Army, Navy, and Air Force for several years have been training the initial increments of men in uniform to perform these tasks. Service schools and technical courses at missile plants already have turned out a considerable number of missile maintenancemen and operators.

An interesting case can be made for the thought that whenever any radically new weapon comes to warfare it calls for the introduction into military service of a new and different type of human being. Some fifty years ago, when airplanes became weapons, it was apparent that aviators must be selected who were somewhat different from soldiers and sailors, primarily because they had a different kind of job to do, and in a new environment. From the beginning, in all countries, new physical standards were required of those to be in aviation. This differentiation and selectivity have been carried out consistently to the present time.

In many respects the missileman and the spaceman of the future will bear resemblance to the airman of the past and present, for missile operation and space flight will be but extensions of the air realm in which aviators have operated for more than half a century. There will, however, be some interesting differences as time goes on between the operators of missiles and space ships and any existing class of military men.

Many aviators have thought that they

operated in a somewhat hostile atmosphere when they found themselves in the clouds over the mountains with a defective engine. Maj. Gen. Dan C. Ogle, Surgeon General of the Air Force, has recently pointed out, however, that space pilots of the future will operate in what he calls "a totally hostile environment." He concludes with this interesting observation:

"THIS we do know—successful Air Force space pilots will be the most emotionally stable, intelligent, highly trained, and intensely motivated men we have."

Dr. James R. Killian, Jr., the President's Scientific Adviser, in his recent report has estimated that it might cost at least two billion dollars to place a man on the moon and get him back again. With an expenditure of this size it is quite obvious that this man will be selected with unusual care.

Dr. George E. Valley, chief scientist of the United States Air Force, in a recent very interesting observation on man in the jet age, has pointed out that the tremendous complexity of missiles and space vehicles calls for a high degree of selectivity for those men who will man, maintain, and launch these new weapons. Another apt conclusion he draws is that, due to the high cost and the one-shot capability of missiles, the great problem will be to give missile operators sufficient training and practice to maintain their proficiency and assure high operational reliability and accuracy.

So it seems that the personnel departments of our services, with their experts in personnel selection, including the physiologists, the psychologists, and, yes, even the psychiatrists, will now be put to work again to determine exactly what are the optimum characteristics for the uniformed missilemen of the future.

Some yardsticks already are fairly evident. Those who maintain the inordinately complicated ICBM's and IRBM's must have a much higher degree of technical qualification than soldiers, sailors, and airmen have possessed in the past. This calls for new personnel classifications and new career incentives.

There was a time when we entrusted our military airplanes to young men in their late teens and early twenties. As a matter of fact, we steadfastly refused through the years to give pilot training initially to anyone over 26 years of age. We entrusted these flying weapons to men to whom we paid a salary comparable to that of a chauffeur or a cook.

These peculiar standards were adopted at a time when airplanes cost less than fifty thousand dollars each. As airplanes became more complicated and as their cost rose into millions of dollars per copy, considerably more selectivity was employed, more experience was required, and more rank and pay were given to the airplane commander.

This experience and observation may point the way to those who will have to determine the characteristics and standards for the missilemen and spacemen of the future.

Another interesting condition which begins to develop is the fact that the physical standards so long employed by the military services may now be discarded. For example, I know at least fifty paraplegics in wheelchairs in one electronics plant who would make a fine maintenance group for the missiles they are helping to produce.

It may be we have at last found a worth-while place in uniform for men who wear glasses and whose bodies do not match their minds—men who are keen, alert, scientifically and technically bent, and who, while they could scarcely meet any of the past physical standards for service, may be exactly what is needed now in the maintenance and even in the operation of missiles.

A LONG time ago it was pointed out that Americans, being technical people whose children could drive automobiles or farm tractors, repair lawn mowers, vacuum cleaners, and other mechanical gadgets, possessed a unique adaptability to the operation of mechanical weapons. Our faith in this fact was somewhat shaken when Russia, largely an agrarian nation, found ample pilots

Technicians fuel the second-stage Vanguard rocket with white fuming nitric acid during static tests (Navy photo).

Army missilemen conduct a checkout of a Redstone missile before simulated tactical firing at White Sands.

and mechanics for her tremendous air forces in World War II.

I still have an abiding faith, however, in the ability of future generations of Americans to meet the stern, new requirements they will face. I have noted, as have many, the eager interest of the young in airplanes and now in missiles.

This was emphasized recently by an incident in the delivery of one of our test missiles from the West Coast manufacturing point to a proving ground in Florida. It appears that one of our giant missiles was placed on a great truck and a tremendous trailer and securely wrapped in canvas. Accompanied by security guards in deceptive uniforms it rolled eastward.

During the first thousand miles no attention was paid to it by anybody. Early one morning the truck drove up to a Texas gas station. A mother in a battered automobile filled with children stopped near by. She said to the station attendant, "Why have they got that big tank wrapped up?" Her 11-year-old son, hanging out a rear window, said, "Mother, don't be stupid, that's a missile."

It looked for a time as though we had double-crossed our children. Just when most boys in grammar school had learned to recognize every airplane which toured the skies, with much greater accuracy than their elders, we put missiles and strange new space vehicles into and beyond the atmosphere. It is already apparent, however, that the interest of the new generation has matched the new requirement.

SOME will query why a reference has been made to those who man missiles. While it is true that most of the missiles in the arsenals are unmanned, it is likely that many of the next generation of missiles may carry a man. This will probably be true for economy, for greater accuracy, and to ensure recovery.

Whatever the requirements for men may be to man, maintain, or launch and operate the missiles in our arsenals, there can be an adequate supply of human material. It but remains to determine whether our leadership will be equal to the discovery, the enlistment, the training, and the provision of adequate career incentive to ensure that we have the best at the right place at the right time.

Among other things, our concept of Reserve forces must be adapted to the missile age. Missilemen must be in place at all times, standing by their weapons. The idea of a Reservist missile operator hurrying to his post after mobilization is impractical and unacceptable. In a missile war, heavy fighting will commence at the very beginning; reaction must be instantaneous. It is conceivable that such a war would be over by the time mobilization, as we now know it, could take place.

This is not to say that we no longer need the Reserves and National Guard.

On the contrary, they may be more vital than ever in a missile war. Upon them, very quickly, would fall the burden of assuring that the country withstood the onslaught of enemy weapons. In a total war involving missiles, the home front will be a battlefield requiring men to combat disorder, sabotage, disaster conditions, and possibly lawlessness. Reserve and National Guard units are in the best position to cope with these problems.

Of the three general categories of people in the space age, the most critical is the commander.

During the last fifty years and during our tremendous activity in two great wars, as a people and as a nation we always have insisted that our military leaders be highly trained professionals. Generally we have ensured this by insisting that they start military training early in life, advance through all the ranks and grades, and become thoroughly acquainted with every weapon they were likely to employ.

Since missiles, satellites, the supersonic aircraft of the future, and all weapons operating above the earth are certain now to be more complicated, more expensive, with tremendously enhanced destructive power, it will be more necessary in the future than it has been in the past that our missile unit commanders have come up through the ranks and are thoroughly familiar by long experience and technical education with the capacities and limitations of their weapons.

Heavier responsibilities will devolve upon the missile commander of the future than upon any man of comparable military rank in the past.

Because of the recognition and realization of these facts, I have had grave concern as to whether our military academies—West Point, Annapolis, and Colorado Springs—have reacted by changing their curricula toward this end. As the battlefield expands from the earth to the heavens, as the weapon grows in complexity, the commander of the future must be better educated, more scientifically and technically minded, and more mature in judgment.

We always insisted in the Air Force that every man who commanded a flying unit be a flier. This paid a great dividend in the Second World War, since all commanders were thoroughly conversant with the characteristics of their weapons and the requirements upon their combat crews. The military leaders in the future must be equally conversant with the weapons of the future.

WHILE I am reasonably aware of the great change which science and technology have brought to warfare, I still cannot see where man, his mind, his energies, and his discretion have been eliminated. As I see it, this tremendous change has merely placed a new emphasis on the requirements for men of new types, more learning, more skill, more courage, and sounder judgment.

Finally, these new weapons make it imperative that we have a new, hard look at military organization at all levels. Superlative weapons and superior manpower can be squandered or sacrificed by defective organization and archaic administration.

The President has been wisely cognizant of this problem in his determination to reorganize the Defense Department. The Army has been mindful of these necessities in forming its Pentomic Divisions and its Strategic Army Corps. The Congress has indicated an encouraging awareness of missilemen in its late act providing increased pay and career incentives to the military.

Whether these sound beginnings are carried to ultimate fulfillment will depend on the continued interest of all our citizens.

The Soviets employ large-caliber mortars as comparatively inexpensive, mobile, short-range artillery (Army photo).

The Red Army

It is not invincible if the Western nations will expand their forces

William V. Kennedy

ARMISTICE Day 1918 dawned grey over Archangel Province, Northern Russia. The air was sharp with the first chill of the lowering arctic winter. Along the Western Front, 2,000 miles away, the guns fell silent. In London, Paris, and New York, crowds danced in the streets.

But at the village of Toulgas, Archangel Province, Company B of the 339th Infantry, U. S. Army, a company of the Royal Scots, and a section of Canadian artillery—300 men and 2 French 75's in all, waited for an avalanche, not of snow, but of fire and steel.

"Hourra! Hourra!" the battle cry of 8,000 Russian throats leaped at the little Allied force.

Out of the forest stormed the lead battalions of the Bolshevik Sixth Army. From the near-by Dvina River, gunboats showered Toulgas with high explosive. Amid the bursting shells and showering lead, the Americans, Scots, and Canadians fought, shouted, cursed, and laughed.

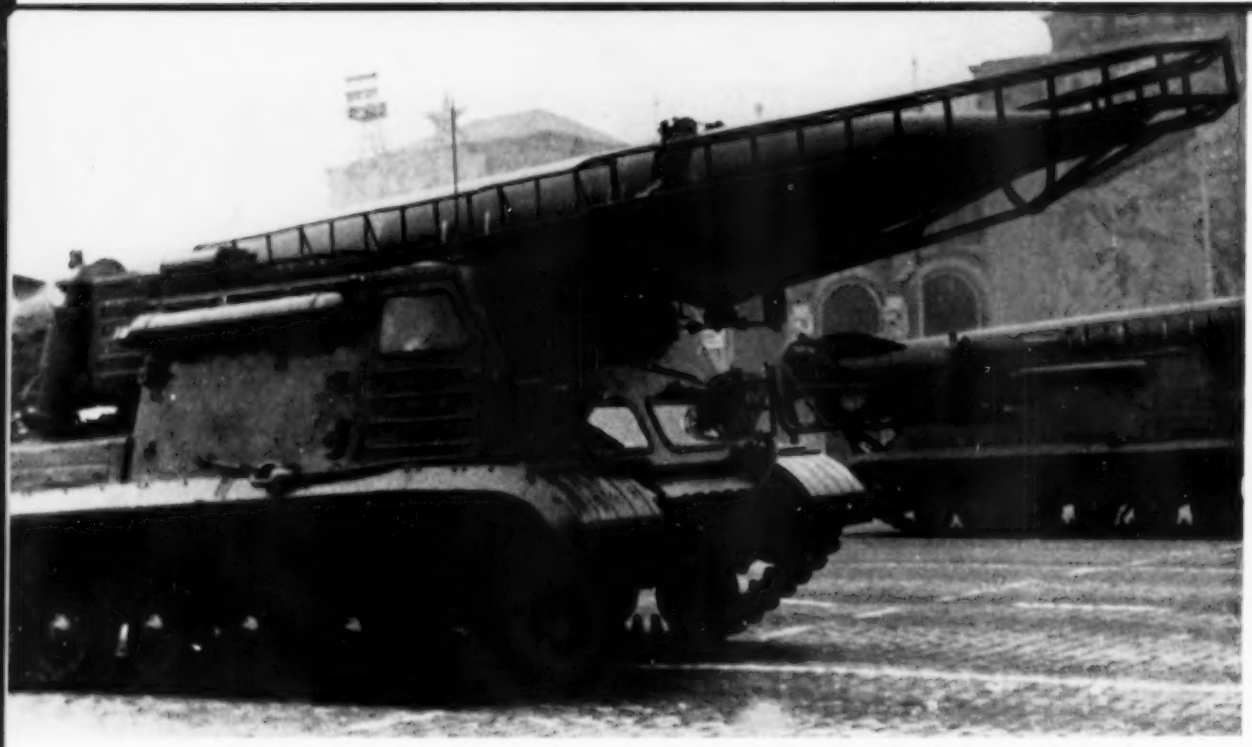
When September came again to Archangel, when the taiga once again flamed in its gorgeous autumn colors, the Allies were gone. But they had marched out, not run. No pursuing Russian had dogged their trail. The Bolshevik Sixth Army, 45,700 men led by Trotsky himself, lay shattered and mutinous in the forest.

We Westerners forgot the Allied Expeditionary Force, North Russia, all too quickly.

Had we taken time to ask, we would have learned from the veterans of North Russia of an army that threw away the lives of its men like so many rounds of ammunition, of a conspiracy aimed at the heart and soul of the West, of a political organization that penetrated to every level of its fighting forces, of a propaganda campaign unprecedented in the history of war.

Had we listened to the Americans who returned from Russian prison camps we would have gotten an inkling of what we were to encounter in Korea.

So it was that in the winter of 1940-1941, having forgotten the 300 who stopped 8,000 at Toulgas, we were astounded when a hastily mobilized, poorly equipped Finnish Army stood



A Russian surface-to-surface ballistic missile, designed to provide close support for field armies (Army photo).

up to the might of Soviet Russia, battled it to a standstill, and wrung from it terms that, while severe, left Finland still a free nation.

"The Winter War," writes Field Marshal Mannerheim, Commander in Chief of the Finnish Army in that conflict and in World War II, "showed that those were right who, for two decades, had held the opinion that our country possessed greater possibilities of defending itself against the giant in the East than our manpower would suggest, and that the nature and climatic conditions and the qualitative superiority of our people could effectively reduce the numerical disproportion."

If this is true of little Finland, lying at the very doorstep of Soviet Russia, then what of the United States, leader of an alliance that includes almost the entire Western world and the holder of immense natural, technical, and human resources?

YET we have convinced ourselves that "we can't beat Russia on the ground." We have gone on from this to almost a desperate reliance on air and missile power to demolish in one great blow the vast empire of Communism, should we ever be attacked. We are coming fearfully close to the point where, if this midcentury version of Maginot Line thinking does not work, we will have rendered ourselves incapable of meeting the challenge that will face us.

BEFORE we reach this point it would be well if we were to determine whether our fear of the Red Army is, in fact, justified.

The present strength of the Russian Army is approximately 2,500,000 men, organized in 175 divisions. This force can be nearly doubled within thirty days by the mobilization of reserves for whom equipment and cadres are already on hand.

Since World War II, the once largely horse- and foot-power Red Army has been rather thoroughly mechanized. Its principal striking force lies in the 22 divisions of the Soviet "Group of Forces" in Germany, and in an airborne force of perhaps 100,000 men. Within the past few years, the twenty-two divisions in Germany have been converted from a preponderately rifle force to an armored and mechanized spearhead aimed at Western Europe.

Approximately ten Soviet divisions are in the East European satellites. Of the remaining 143 divisions, most of them understrength, the bulk are concentrated in the Soviet Far East or echeloned against the Soviet's sensitive southern frontier.

Behind the Russian Army are the European satellite and Chinese Communist armies, even larger, in the aggregate, than the Soviet Army itself.

The Russian Army remains, however, the crucial element of Communist power. If the Russian Army is brought to battle and destroyed, and if the Russian industrial and transportation systems that are the heart and the lifeblood of the Communist empire are laid waste, the fate of the allied Communist powers will be sealed.

Within the Russian government, the Red Army dominates the rest of the military structure.

GUIDED missile development is under the direction of an artillery marshal. The Minister of Defense himself has always been an Army officer. A vast proportion of Russian air power, possibly 10,000 combat aircraft, is organic to the Army. The remaining 10,000 or more first-line aircraft, whether they be the bombers of the Long Range Air Force or the fighters of the air-defense system, are subservient to and an instrument of Army doctrine.

Armor, to the Red Army of today, is

The Soviet 15-mile rocket mounted on amphibious tank chassis results in a weapon of high-utility (Army photo).

the arm of decision. Of its present 175 active divisions, over one third are classified as "Tank" or "Mechanized." Behind them are the great mass of rifle divisions, reëquipped since World War II for their rôle of breaching a gap for the armored divisions or of holding and organizing terrain overrun by the armored armies.

With all these divisions, Tank, Mechanized, and Rifle, move the masses of artillery which the Soviets still consider essential for the creation of a "zone of death" in front of their attacking columns.

ATOMIC weapons of all sizes have been integrated into the Soviet armed forces as a supplement to rather than a replacement for the older weapons.

The entire Soviet strategy—land, air and sea—is based on a mighty "strategic thrust," geared to reach its objectives within a few days. Thus even a massive bombardment of the United States would be, in Soviet eyes, only "supporting fire" for the ground assaults in Europe and the Middle East.

Unless sufficient forces are available on the ground, as well as in the air, to stop the initial Soviet assault, the Red Army can overrun Europe and the Middle East before even the most devastating atomic bombardment of its homeland can take effect. With these two areas in its possession, the Soviets would be on their way to world dominance.

From the standpoint of defense, the Red Army has, at least at first glance, an advantage in its interior lines of communications, by which it would appear to be able to shift forces rapidly to any threatened point. The attacker, on the other hand, is forced to move around the vast Soviet periphery.

In carrying out either offensive or defensive operations, the isolation of the Soviet soldier from any true knowledge of world conditions, constant indoctrination by political officers, and an effective network of secret police informers would seem to give the Soviet assurance of an iron discipline and uniformity of thought and action.

It is in this last area, however, that the chinks in the power of the Red Army are most apparent.

Mr. Kennedy is an officer of the 104th Armored Cavalry Regiment, Pennsylvania National Guard. He is former executive editor of the Pennsylvania Guardsman.

Every contact the Soviet Army has made with a Western army, whether that of Hitler or of the Allied forces opposite to it now in Western Germany, have produced the phenomenon of numerous defections, not only by misfits and criminals, but by competent, highly trained men. Even in Hungary, where there was no direct contact with an organized Western army, substantial numbers of Soviet soldiers went over to the Hungarian rebels in October and November 1956.

THAT the morale of the Soviet Army is not all it should be and that it has never been all it should be, even when large portions of the Red Army were defending the soil of Russia heroically, is documented by too many instances of defection, rout, and mass surrender to be ignored.

What would happen to this Army if it were exposed to a powerful propaganda barrage, backed by solid, imaginative Western policy commitments, only can be surmised.

Open to more precise assessment, however, are several great technical weaknesses within the structure of the Red Army that if played to our advantage can change the entire aspect of the Soviet menace.

First, the Soviet division, unlike our own, is not intended as a self-sustaining combat organization. Its small divisional logistic "slice," so much admired by would-be defense economizers in the West, prohibits sustained combat for more than a few days. The Soviet corps, of two or more divisions, is not much better off.

Only at army level do we find the logistic "tail" for the fighting forces. Even here, however, the logistic system is so truncated as to prohibit continuous offensive action lasting for more than a fortnight.

Awesome though the Soviet offensive power may be, it is a power that must succeed quickly. If it is stopped short of its objectives and if strategic air and missile power are able to inflict significant damage on its rear areas, the chances of the ponderous machine getting going again are slim.

A SECOND major technological weakness lies in the Soviet transportation system.

Only in European Russia and in the Maritime Provinces of the Far East is there anywhere near a sufficient road and rail network. The rest of the vast empire is held together by airlines, by tenuous rail links, such as the Trans-Siberian, by even more tenuous sea routes, and by an anemic road net. In the wilderness of Northeastern Siberia, terrain and weather have prevented the building of even a skeleton road net.

Thus, powerful though the Red Army may be and advantageous though its interior position may appear, it is severely limited in its ability to move and to concentrate adequate forces at the thousands of points of possible attack around the Soviet perimeter.

This is precisely the difficulty that enabled an 11,000-man Allied Expeditionary Force in North Russia to resist and to defeat the armies of the Russian Revolution. It was a factor even on the fringes of highly developed European Russia during the Russo-Finnish Winter War of 1940-1941.

A third serious weakness is the historic lack of flexibility and individual initiative of the Russian soldier himself. This went to such extremes in World War II that in more than one instance

"Beyond the power to check the initial blow of the Soviets and to retaliate, by air, against Russia itself, there must be a capability of obtaining an ultimate decision."

Russian infantrymen lay mute, waiting for German tanks to crush them because, having lost their commander, they were unable or unwilling to act on their own.

The Russians appear to have recognized that such bovinity has no place in the atomic age. Just how much can be done to change instinct built up over the centuries and just how much freedom of choice a Communistic system can permit, even in the dispersion of the atomic battlefield, is questionable.

Fourth, and in many ways the most significant of the flaws in the Red Army, is its own dominance of the Soviet defense structure.

World War II experience and the added consideration of atomic firepower have convinced the military leaders of the North Atlantic Alliance that, given a NATO force of thirty divisions, they can stop the initial "strategic thrust" of the Red Army.

Unfortunately, we lack not only the thirty divisions but any clear idea of what is to be done once the Red Army is stopped.

The concept of a "sword" of strategic air power somehow bringing the Soviets to book while a weak or nonexistent "shield" of NATO land power holds the Red Army at bay makes for attractive newspaper copy but not for an effective strategic plan.

FORTY-ONE years of experience in dealing with Communist governments should have convinced the West that the Soviets will negotiate only to gain time to recuperate and to strike again. If, having devastated Russia and having been battered ourselves in return, we are willing to settle for a return to the status quo, then millions of lives will have been sacrificed for naught.

The situation demands a more complete and more far-reaching solution than can be provided by Madison Avenue slogans.

As the Western Alliance continues to reduce its land power, both regular and reserve, the prospect that the initial Soviet sweep into Western Europe and the Middle East will succeed becomes steadily brighter.

The build-up of the NATO forces to the required minimum of thirty divisions is but the first step necessary to establish an effective counterpoise to the Red Army.

BEYOND the power to check the initial blow of the Soviets and to retaliate, by air, against Russia itself, there must be a capability of obtaining an ultimate decision. Such a decision can come only through a counterattack, on the ground, that not only ends Communist power once and for all, but provides the means of reorganizing the liberated territories before they fall into utter chaos.

The United States has available in the armored formations of the United States Army and the Army National Guard the potential to create both the active and reserve forces required.

We can realize this potential only if we hasten the modernization and expansion of our existing armored forces and accelerate the conversion of the bulk of our infantry divisions, both Regular and National Guard, into lightly armored mechanized forces capable of keeping pace with the heavier divisions. We must, in addition, provide those forces with the sea and airborne logistical support needed to transport them overseas and to sustain them on a vastly expanded battlefield.

The Red Army is, in many ways, a gigantic bluff. And no one knows this better than its masters. Each time the bluff has been called, whether by a handful of Americans, British, and French in North Russia in 1918, by Finland in 1940 and 1944, or by Hungary in 1956, the goliath has shown great and potentially fatal weaknesses.

If war comes, the United States and its Allies have the means to halt and to crush the Red Army. To throw away those means now, in the name of a false economy, or in the belief that effective resistance on the ground is hopeless, would be capitulation, not to superior force, but to the appearance of force.

AMERICAN ARMAMENT, VI

SEABORNE ORDNANCE of the United States NAVY

An outline of the seaborne weapons — both operational and developmental — of the United States Navy, designed by engineers and scientists of the armed forces, educational institutions, and industrial organizations and produced by American industry for the national defense of the United States.

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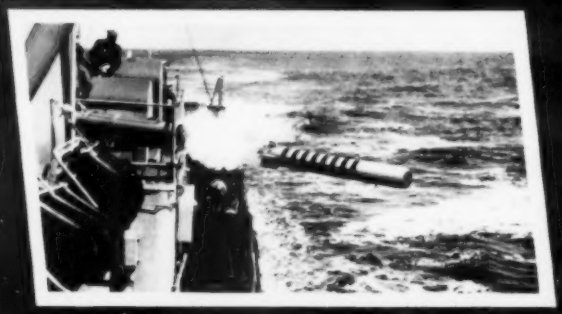
ORDNANCE

Bimonthly Journal of the American Ordnance Association
Washington 6, D. C.

The guided missile cruiser *U.S.S. Boston* left, typifies the Navy's gradual transition from guns to missiles. She is armed with two 8"/55 triple turrets forward, five 5"/38 twin mounts, and six 3"/50 twin mounts. Af are two dual Terrier antiaircraft automatic loading missile launchers with their radars for missile guidance. Guns will give way to all-missile batteries in new ship construction.

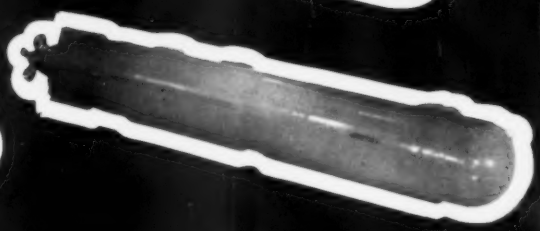
TORPEDOES

A Mark 43 acoustic homing torpedo being launched from the single deck tube of a destroyer-escort vessel. It is a versatile offensive weapon against hostile submarines.



Another acoustic homing torpedo, the Mark 32, especially designed for antisubmarine defense by surface ships. Its new guidance system permits it to be side-launched.

The Mark 37 torpedo is adaptable to surface or submarine use and incorporates several new devices that are reported to give this new weapon great versatility in homing.

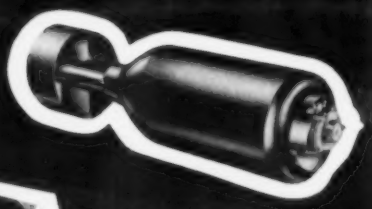


Single fixed tube for launching torpedoes from small combat ships. Although the chief gunner's mate is about to close the firing switch, it can be fired from the bridge.

SEABORNE ORDNANCE of the

ANTISUBMARINE WEAPONS

Weapon A, developed after World War II, is a sophisticated form of depth charge, here being fired from an ASW destroyer and directed by sonar fire control.



The lightweight picket-boat depth charge recently developed by the Navy Bureau of Ordnance for harbor defense. It is believed to have a homing device and proximity fuze.

Close-up view of the Navy's latest underwater weapon, the rocket-assisted torpedo (Rat), 13½ feet long, weighing 480 pounds. A parachute deploys before impact.

The Rat is shown here being fired under its own rocket power from a launcher attached to a destroyer's 5"/38 gun mount. It greatly extends the ship's striking area.

The United States NAVY

The arma
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GUIDED MISSILES

The Regulus II surface-to-surface guided missile has a speed of Mach 2 and a range of 1,000 miles. It is powered by a turbojet engine and can carry a nuclear warhead.

Regulus I is a surface-to-surface missile with nuclear capability, guided by an electronic "brain." With a speed of about Mach 1, it can be fired from ship or shore.

Shown here are Terrier guided missiles and launchers on the cruiser BOSTON. A surface-to-air all-weather weapon, Terrier can strike at aircraft up to 10 miles away.

Talos is a surface-to-air, 3,000-pound supersonic missile with nuclear capability and 2-stage guidance. It is powered by a solid-propellant rocket booster and a ramjet.

Polaris, now undergoing development, is a solid-fueled, intermediate-range ballistic missile designed to be fired either from ships or from submarines while submerged.

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mament carried by our naval forces afloat includes
oes, antisubmarine weapons, guided missiles, and
all designed to help the Navy carry out its tradi-
ole of enforcing freedom of the seas, defending
ores from hostile attack, and keeping open sea
unications with our allies and overseas bases.

GUNS

0-mm. twin- and quadruple-
nted automatic cannon were
e backbone of our World War
II kamikaze defense. They now
have inertial fire-control devices.

e 3"/50 antiaircraft gun in twin
mount with Mark 63 gunfire con-
trol system, including radar, is the
main antiaircraft defense of all
fleet destroyers and larger vessels.

The 3"/70 twin-mounted antiair-
craft gun for heavy destroyer lead-
ers. Latest electronic fire-control
devices with fully automatic loading
give great accuracy and firepower.

The 5"/54 gun in double-purpose
mount is on FORRESTAL-class car-
riers and MITSCHER-class destroy-
ers. It has self-contained fire con-
trol and a very high rate of fire.

These 8"/55 triple turrets, the
main battery of all heavy cruisers,
still can give accurate support to
landing operations. Guided-missile
cruisers are replacing such ships.

THE AMERICAN ORDNANCE ASSOCIATION

announces with pride

Two Timely and Important Forthcoming Meetings

A SOUTHWEST REGIONAL MEETING

Under the Auspices of the Rio Grande Post, A.O.A.
At El Paso, Fort Bliss, and White Sands Missile Range

WEDNESDAY, OCTOBER 8, and
THURSDAY, OCTOBER 9, 1958

TOPIC: MISSILE PROGRESS

- Members will have an opportunity to visit the Army Missile Center at Fort Bliss, Tex. Members will attend briefings at White Sands, N. Mex., and witness current missile tests and demonstrations.
- Invitations have been issued to all company members and individual members of the Rio Grande, Albuquerque, Lone Star, Los Angeles, Louisiana, Mid-Continent, New Orleans, Rocky Mountain, San Francisco, and Texas Posts.
- All other members will be welcome: Apply to National Headquarters for reservations. Reservations close September 24, 1958.

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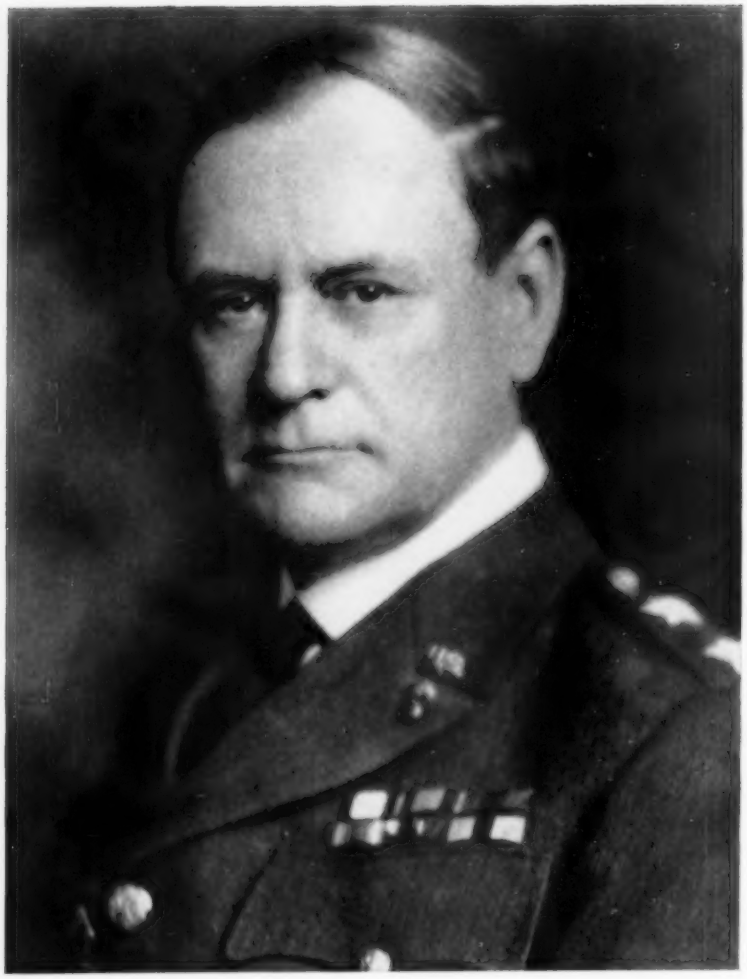
FORTIETH INDUSTRIAL PREPAREDNESS MEETING

Under the Auspices of the New York Post, A.O.A.
At the Waldorf-Astoria, New York City

WEDNESDAY, DECEMBER 3, 1958

TOPIC: RESEARCH FOR DEFENSE

- There will be daylong seminars in which outstanding authorities of the Defense Establishment, science, and industry will participate.
- The annual Industrial Preparedness Dinner Meeting will be held in the ballroom of the Waldorf in the evening.
- Invitations will be issued early in October to all company members and to individual members of the New York, Capital Cities, Empire, Hartford-Springfield, Philadelphia, Washington, and Yankee Posts.
- All other members will be welcome. Apply to National Headquarters for reservations. Reservations close November 17, 1958.



Maj. Gen. C. C. Williams

Born November 8, 1869 • Died June 11, 1958

MAJ. Gen. C. C. Williams, renowned Chief of Ordnance of the Army in World War I and for twelve years thereafter, died at his home in Woodstock, Va., on June 13, 1958, in his eighty-ninth year. He was one of the founders of the Ordnance Association and from its establishment in 1919 until his death was an active and enthusiastic supporter of its ideals and activities. To commemorate his life and work the Association established in 1930 its Williams Gold Medal and in that year made the first award of the medal to him.

For the past decade General Williams had lived with his sisters in the restful countryside of the Shenandoah Valley. Death came quietly and suddenly. Funeral services were held in Woodstock on June 16th, followed by burial with full military honors that afternoon in Arlington National Cemetery.

In attendance among many of the General's friends and admirers were Maj. Gen. John H. Hinrichs, Chief of Ordnance of the Army, and Maj. Gen. August Schomburg, Deputy Chief of Ordnance.

Representing the American Ordnance Association were Lieut. Gen. Levin H. Campbell, Jr., Chief of Ordnance of the Army in the Second World War; Maj. Gen. James H. Burns, formerly Assistant Secretary of Defense; Maj. Gen. James K. Crain, who was United States executive on the London Munitions Assignment Board during the Second World War.

Also, Maj. Gen. Harry K. Rutherford, formerly assistant to the Secretary of the Army; Maj. Gen. R. L. Maxwell, Assistant Chief of Staff in charge of Supply in the Second World War; Brig. Gen. Earl McFarland, formerly chief of Ordnance Field Service; Brig. Gen. Burton O. Lewis, formerly assistant chief of Ordnance Industrial Service; and Col. Leo A. Codd, executive vice-president of the Ordnance Association. All had served formerly under General Williams.

Legacy of Ordnance Service

A tribute to the life and work of Maj. Gen. C. C. Williams

THE life and work of General Williams marked an epoch in the industry-armament relationships of the United States. They came at a crucial time in the progress of our country to its position of world power. They will hold a place in American history symbolizing the impact of the industrial revolution on modern warfare.

General Williams was closely identified with ordnance development during the first half of the twentieth century—an era which has witnessed the development of weapons of power and on a scale unknown throughout all recorded time until now. His place in that achievement is high and permanent.

In the pages of this journal since its inception nearly forty years ago, the plans, policies, attitudes, and results of General Williams' leadership have been described in full; now we appraise some of them in retrospect for their bearing on the present and the future.

General Williams was a leader of men who dealt in the broadest of problems and viewed them in their widest aspect. He thus filled the rôle of the ancient Greeks who achieved greatness as leaders because of their talents as teachers.

Viewed in retrospect, the Williams' philosophy of ordnance preparedness was based upon a few—not more than half a dozen—basic principles. Their application at the time was novel, and their effect was to advance the national defense in a very striking way.

General Williams came upon the Army scene at a time when there was great need for giving the soldier the type of weapon he needed rather than the kind the ordnance engineers thought best for him to have. A basic tenet of the Williams' philosophy, which guided his administration of the Ordnance Department and has likewise guided the policies of all his successors, was simple in statement and in attitude. It was: We must design and procure the weapons our fighting men want and make those weapons of the best quality to meet quantitative requirements and at the lowest cost.

GENERAL Williams operated on the principle that maker and user of ordnance must work in close harmony. He established within the Ordnance Department first the Ordnance Technical Staff and then its collateral group, the Ordnance Committee. Here were novel methods of keeping ordnance research and development not only attuned to the scientific and industrial capabilities of our country but to the needs of the fighting forces.

The Ordnance Committee became a vehicle for gathering together regularly the points of view of the various combat services—Infantry, Field Artillery, Coast Artillery, and Cavalry—side by side with the technical craftsmen.

To General Williams also goes the credit for establishing the Ordnance District System, the prime purpose of which was and is to decentralize contacts and operations of Army Ordnance to bring them into closest possible harmony with scientific and industrial capabilities. He saw and experienced the evils of concentrating in the Nation's Capital the actual operations of so vast an establishment as the science-industry-ordnance organization.

HENCE, early in World War I he brought together some of the best industrial talent under whose guidance he established the system with its centers of contact in all the main industrial areas of the United States. He placed these centers under the guidance of well-known industrial leaders whose judgment he fortified with some of the best talent of Regular Army Ordnance officers.

Likewise, General Williams instilled in all his associates, both in the military service and in industry, the importance of the industry-arsenal copartnership—a relationship which frequently is misunderstood. But when followed according to the Williams' formula its logic is so sound and its facts so compelling that one is forced to the conclusion that the principle is correct.

Simply stated, the Williams' thesis for the industry-arsenal copartnership was this: Arsenals are necessary in normal times for keeping alive the techniques of minimum armament research, design, and pilot-line production.

Another achievement for which General Williams deserves fame was the manner of his executive leadership. With wise insight he selected officers and industrial coworkers and gave them unlimited authority to get the job done. Delegation of authority was one of his major methods of administration. The result was the successful operation of a vast industrial-military enterprise and, at the same time, the development of executive ability on the part of those who participated in it.

Finally, mention must be made of the American Ordnance Association which was started with his blessing as the Army Ordnance Association in 1919. He was one of the founders, and he participated in guiding the organization throughout its early years. He rallied to it many industrial leaders and made them conscious of the need for industrial preparedness. He watched its growth with pride and, throughout the years of his retirement since 1930, was constant in his solicitude for the Association's success.

General Williams was graduated from the United States Military Academy in 1894, after appointment from his native Georgia. Throughout his long and useful life he portrayed the best traditions of his alma mater, and he left as a legacy to those who follow him, both in the military service and in the Ordnance Association, a heritage of sound thinking, broad attitude, and loyalty to ideals which will make his name revered by the entire Ordnance fraternity.—L.A.C.

Soviet Science

In Russia, science and engineering students receive stipends and bonuses in addition to free tuition, and after graduation they earn high salaries and are much less subject to political supervision

James W. Useller

THE alarm with which the American public viewed the launchings of the Soviet satellites pointed out how little the man on the street knows about the Russians. We are particularly unaware of the Soviet capabilities in the field of science and technology.

This lack of understanding is inexcusable, for several research groups exist on American campuses that have been studying the Russian society and its operation for many years. The centers at Stanford and Harvard Universities, as well as that at the Massachusetts Institute of Technology, have been concerned particularly with Russian scientific efforts.

The following material is based on scholarly papers published by these centers and on other available accounts of Soviet efforts in science.

The Soviet Union has a scientific heritage that dates back over two hundred years. The first effort to organize the scientific skills in Russia was begun by Peter the Great in 1724. He called for the establishment of a scientific forum that would plan and guide the technical effort of the nation. In the following year, 1725, the Imperial Academy of Sciences was founded. Although Peter was primarily interested in the immediate benefits that science could bring to his nation, he subsequently learned to appreciate the vast potential of basic research whose benefits are often not realized for years.

Mr. Useller is with the Propulsion Systems Division of the National Advisory Committee for Aeronautics, Cleveland, Ohio.

Peter's plan for the Imperial Academy of Sciences was not only to serve as an institution of scientific research, but also to coördinate and supervise the country's entire educational system. It was to coördinate all phases of Russian science from the education of aspiring students to the actual conduct of research.

Unfortunately, the plan itself was not sufficient to achieve the desired result. Eighteenth-century Russia had very few scholars with whom to populate the newly formed Academy, so that it was natural to turn to the scientific centers of Western Europe for ideas and encouragement.

The first members of the Imperial Academy included many Western intellectuals who were to vitalize the ambitious plan of the Czar. As might be expected with such a grandiose plan to organize all Russian science, the details were neglected, and in the end little was accomplished.

In 1747 the Academy was separated from its supervision of the colleges and universities and began to function solely as a research organization. It stimulated and coördinated scholarly thinking, founded the development of individual sciences, and sponsored the establishment of several universities.

During the nineteenth century, Russian scientists traveled widely throughout the world to discuss their various specialties with the prominent scholars of the day, and many foreign scholars were elected to the Russian Academy of Sciences. There was a complete exchange of fundamental scientific knowledge between the Russian scientists and those men of the Western world who were founding what we call modern science.

DURING World War I the desperate plight of the Russian Government forced many scientists to abandon their research and to apply their skills to the development and production of weapons for immediate use. The government failed to recognize that a fundamental difference existed between the pursuit of knowledge and the ability to apply it to the production of quantities of weapons for a modern army. Much of the effort of the Russian scientists of that time fell short because of the lack of supporting technology and industry.

Following the revolution in 1917, the Soviet authorities were quick to grasp the significance of the scientific community of the nation and provided extensive funds for resumption of the basic research effort. The scientists again became an elite group. Unfortunately, however, they were not exclusive enough to escape the purge that spread throughout Russia in 1929, and many

prominent scholars were exiled or disappeared.

About this time the Academy of Sciences was brought into the government and subordinated to what is now the Council of Ministers, at the top of the governmental hierarchy. Thus all scientific effort was concentrated and could be controlled politically by the government in power.

WHEN the purge subsided during the later 1930's, emphasis was again placed on practical research that could be applied to strengthening the military might, and this effort paid off in the early years of World War II. Western observers remember the effectiveness of the "Katushka," the first tactical rocket weapon that the Russians threw against the Germans.

This success should not have surprised the world, for the Russian scientist K. E. Tsiolkovskii was already recognized as an accomplished researcher in rockets before the 1930's.

In 1946, Stalin gave the Russian scientists the task of reaching and surpassing the scientific achievements outside the U.S.S.R., and politics again began to exert an influence on Russian science. During the Stalinist era many scientists had to accept certain politically dictated "truths" and often had to spend valuable time corroborating them. Since the death of Stalin, there has been another relaxing of direct political interference with scientific research, but of course the political control still remains.

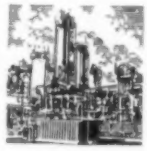
ALTHOUGH during its more than 200-year history Soviet science has been harassed with periods during which the political leaders have interfered with its operation and progress, its history is also studded with the brilliance of some of the world's greatest scientific luminaries such as Mendeleev, Pavlov, and Semenov.

The basic aim of education within the Soviet Union is to prepare the individual for "service to the state." This fundamental characteristic is emphasized to the extent that all rights, desires, and choices of the student are subordinated to the plan of the state.

The Soviet educational philosophy rests on three major premises. The first of these is that the advancement of science and technology is best promoted through central planning of education and research; secondly, that scientific and educational efforts are primarily a means for the advancement of the social, economic, political and military interests of the nation; thirdly, that the basic truths of human life, of nature, and of the universe have been discovered and are beyond debate.

The task of the teacher and scholar is therefore to demonstrate and apply these truths rather than to question them or seek alternative solutions.

The latter principle is consistent with the Soviet desire for conformity and the fear of independent thinking or action that might result in opposition to the established system. In time, the last of these principles may be the undoing of Soviet science.



While these principles imply considerable coercion to conformity to dogmatic beliefs, the Soviets have been realistic enough to insist on technical competency and applied technical know-how.

Soviet educational planning begins, quite naturally, with the secondary level. Compulsory secondary education is comparatively new in Russia except for the large cities, being introduced in 1949—and then school attendance was required for a total of only seven years. The 10-year school only recently has become compulsory in urban areas, and it is not expected to become obligatory throughout the U.S.S.R. until 1960. This timetable has been dictated by the shortage of available teachers and facilities rather than by plan.

Upon completion of the 10-year school, a student may be shunted to factory employment, or if he is sufficiently successful in the state examinations, he may be allowed to attend a trade school, a technicum, or even a university. Only the academically gifted are permitted to indulge in the advanced phases of training such as the university. In most cases, fees and tuition are absorbed by the state and the student is given a stipend.

At a large university an engineering or science student is paid a stipend equivalent to $100 a month over and above his normal educational expenses. Outstanding academic achievement results in the payment of a bonus, often as high as twenty-five per cent extra.

Students are screened by examination at each level of education. A university graduate may be diverted to a state-assigned job, or he may be permitted to continue with further study, depending on his examination score.

Graduates of the technicums, which correspond somewhat to institutes of technology in the United States, but whose curricula are more specialized, are required to work for three years in an assigned job, after which they may go on to the university for further study. The top five per cent of a class is exempted from compulsory work to permit study for a doctorate.

ALTHOUGH the student selection plan appears to be based completely on ability, there has been recent complaint in Russia of the use of *blat* in the selection of students for the higher institutions. *Blat* is a combination of political and personal influence, either on the part of the student or his family, but actually this affects only a small percentage of the Soviet students. Political reliability, however, as well as an individual's background are often as important as a high I.Q. in the selection process.

There are thirty-three universities in the U.S.S.R. that offer more than sixty courses of study. In general, they are based on 4,500 to 5,500 hours of instruction with the number of subjects ranging from twenty-five to thirty-five. Russian university programs are generally five years in length. At present the number of instruction hours per academic year is anywhere from 1,000 to 1,300, or about twice that in U. S. universities.

"Some Western scientists have suggested that the Soviet educational system has produced a situation under which the Russian scientists can exploit the research findings of the West so long as the Western technicians point out the significant problems."

In addition to his classroom work the Soviet technical student has four 4-week practice periods during which he actually works in a factory with a regular assignment to add a practical background to his classroom study. This is similar to the coöperative plan of some American colleges, except that it is done by the Soviet student during his vacation periods and he usually has no choice in the assignment.

It appears to be the policy of Soviet educators to foster the "task-force" approach. That is, they will train and organize a group of scientists to study a particular problem, such as jet engine technology. This tends to give a spasmodic or scattered appearance to some of the Soviet research. It emphasizes immediate application to short-range aims—to the possible detriment of fundamental long-range research.

Some Western scientists have suggested that the Soviet educational system has produced a situation under which the Russian scientists can exploit the research findings of the West as long as the Western technicians point out the significant problems. The Soviets, it is claimed, will be able to solve these problems as rapidly and as effectively as Western groups, but the ability of their research groups to uncover and formulate new problems is questioned.

THE "task-force" approach leads to the conclusion that although Soviet science can make spectacular gains in particular areas, it is not founded on the broad base of knowledge and understanding needed to sustain a healthy program of technical advancement.

The Soviet authorities have decreed that the primary task of education is to produce a sufficient number of qualified technicians and scientists to serve the objectives of the state. The political leaders decided that the advancement of the Soviet society rested on the availability of trained professionals to gain the required technical leadership. The program of preparing the badly needed professionals began in 1920.

The most important occupations in the Soviet Union, by far, are those in engineering and science. They command high salaries and offer outstanding prestige and status advantages. Professional occupations in the fields of agriculture, medicine, law, and the social sciences are far less rewarding and, in many instances, are actually more politically hazardous than engineering and science.

During the last tweny-five years the regular student enrollment in Russian higher educational institutions has increased sixfold, reaching 1,100,000 in 1954. The total enrollment during this period was supplemented by an extensive system of extension courses offered throughout the U.S.S.R. These extension courses accounted for an additional 645,000 students in 1954.

The college and university population in the United States during the past twenty-five years has been consistently double that of the U.S.S.R. If the academic population is evaluated per capita of the national population, it is obvious that the Soviet Union lags behind the United States to a considerable degree.

To understand the influence of the total number of students on the potential of Soviet science, it is more significant to study the engineering and science college enrollment. At the peak of the expansion of engineering training in 1932 it accounted for some fifty per cent of the student enrollment.

During the late 1930's, the training of teachers began to predominate, and this trend continued into the postwar period, pushing engineering enrollment into second place. Despite this, engineering students in most years accounted for more than thirty per cent of the total enrollment.

The Russian graduating class of 1954 contained about forty per cent less than the number of bachelor degrees awarded in 1953 by American colleges and universities. The astounding thing is that in the Soviet Union over sixty per cent of the graduating classes of 1954 were composed of engineering and science majors.

In the United States, less than twenty-five per cent of our 1953 graduates were in these fields. Thus, in 1954, the Soviet Union, with substantially smaller total graduating classes, produced more than twice as many engineers as the U. S.

In 1953 the United States had an estimated 5.8 million persons who had completed higher educational courses leading to a degree. The Soviet Union could count only about 2 million. However, in the applied scientific fields, such as engineering and medicine, the number of Soviet professionals who had completed higher education equivalent to a bachelor's degree was about equal to or somewhat above the number of such persons in the United States.

IT is nearly impossible to evaluate the quality of these vast numbers of Soviet scientists and professionals. The Soviets probably have as fair a number of first-class scientists per capita as any other civilized country, but the research ranks are judged to be filled by a large number of people of indifferent quality.

In spite of its rather confused beginning over 230 years ago, the Academy of Sciences has emerged from Russian history to be the center of all scientific accomplishment in the Soviet Union. Only recently has it become an agency of the central government with full power to direct all scientific work.

The Academy is divided into eight departments, each of which is charged with controlling the research work of particular fields of science. The scientific departments operate institutes which conduct the basic research in the Academy as well as supervise commissions that operate between departments.

One such commission is the now famous "Commission on Interplanetary Communication" headed by Academician Leonid I. Sedov. Late in 1955 this group was assigned the task of designing and building a vehicle for space research. The degree of their success was made known to the world when, on October 4, 1957, they launched the world's first orbiting satellite.

This same group repeatedly has been reported to be planning a vehicle to be landed on the face of the moon. In November 1955, Y. S. Khlebysevich predicted that "in the next five to ten years the conquest of our nearest celestial body can become a fact."

Although the political leaders in Russia have recognized that great harm can be done to scientific progress when

political control becomes too rigid, they have not completely relaxed their control over the scientists. They maintain that since science is an integral part of the Communist plan, the scientific community also must conform to the basic principles of Communism.

The political guidance of the Academy of Sciences is vested in a small group named the Scientific Secretariat. This group prods the scholars to perform their rôle with efficiency, precision, and devotion.

THE Scientific Secretariat does not dictate what research is to be carried out by the various research groups, but simply is a means of keeping the political leaders informed of the type of work being performed. Thus they are able to affect their control more systematically. Actual decisions regarding the type of research to be conducted originate with the Presidium of the Academy of Sciences. The Presidium is made up of the top-level scientific members of the Academy assembled as a governing body.

The total staff of the Academy of Sciences numbers between 20,000 and 30,000, of whom one-third are scientific workers. There are currently between 165 and 220 scientists in the Soviet Union who hold the rank of Academician. Although Academicians are elected from all the states of the U.S.S.R., a large majority are from the Moscow-Leningrad area.

THE status of the Russian scientist in his society is not only important in regard to the personal gains that may evolve on the individual but also as to how it influences aspiring young scientists to enter the field. Even though most of the choice of whom and how many persons may enter the higher educational institutions rests with the state in Russia, the government has recognized that the individual must be activated by either personal gains or higher motives. In fact, the importance of these motivations has been deemed so high that the Communists have resorted to using most of the incentives that they have denounced in the outside world as being decadent and capitalistic.

Russian students of science and engineering begin to enjoy the benefits of their profession while they are still preparing themselves for future employment. Although fewer than ten per cent of the students in Russian universities pay their own tuition and expenses, the science students are given even further special considerations. A science or engineering student receives, in addition to his normal tuition, a stipend that is from one-third to one-half more than that received by a medical student, for instance.

"The Soviets probably have as fair a number of first-class scientists per head of population as any other civilized country but the research ranks are judged to be filled by a large number of people of indifferent quality."

The science student enjoys at least one other advantage over his colleagues in other fields of study in Russia. Although the Soviet Military Service Act does not mention the deferment of students, a decree by the Council of Ministers of September 1943 listed some eighty-five technical schools whose students were to be exempted from military service.

Exemptions, and not mere deferments are given rather generously to scientific and engineering students. All other Russian students are subject to conscription in their 18th year, whether or not they are in a higher educational institution.

There has been a concerted effort on the part of the Soviet government to increase the prestige of their scientists both at home and abroad. Within the Soviet Union, the scientist currently enjoys the highest level of personal prestige, sometimes overshadowing that of the top political leaders.

The Soviets also have not neglected the materialistic advantages to their men of science. Consider what might be called a typical Russian scientist. He is in his early thirties and probably has a candidate's degree, equivalent to a master of science degree. He is in charge of a small working group of five or six technicians and junior scientists.

He earns about $10,000 a year, tax free. He is given a housing allowance and a comfortable house for his family. His wife has two household servants and there are two automobiles in the family garage. The last point is more significant than it would be for most Americans, for the average Russian worker has little hope of owning an automobile in his lifetime.

TOP Soviet scientists, of course, are paid much higher salaries and also accrue even greater advantages. Recently, a recognized Soviet scientist said that his annual salary would be equivalent to about $45,000 in the U. S.

He receives a substantial salary as a professor in a technicum. At the same time, he directs the research efforts of a group in the Academy of Sciences. This assignment increases his basic salary by fifty per cent. Many top scientists also hold positions as industrial consultants for which they receive an additional fifty per cent.

The Russian government awards fifty prizes each year for outstanding scientific achievement. These range from $3,000 to $25,000 and are tax free. Outstanding achievements are rewarded by larger special prizes; for example, a top Soviet aircraft designer was awarded $100,000 a few years ago for the design of a supersonic airplane.

Perhaps the greatest advantage that the Soviet scientist enjoys is his relative freedom from political intervention. In a country where every action and work must be weighed as to its conformity to established political doctrine, it is a distinct advantage to be able to live and function with comparative political freedom.

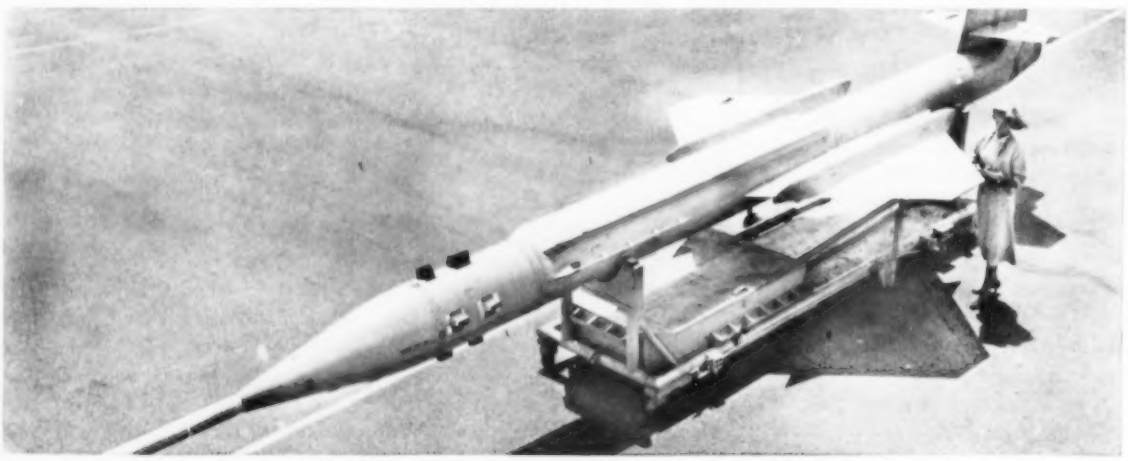
Despite continuous campaigns to recruit professional personnel into the Communist party, less than one-third of the professional personnel in the Soviet Union are party members. Most Russian scientific personnel appear to be indifferent to politics.

IT may be expected that as long as the government of the Soviet Union provides her scientists with good foundations in learning, adequate facilities for operation, and the numerous personal advantages offered today, these scientists will serve their nation well.

In the Missile Arsenal

The Air Force TM-76 Martin Mace surface-to-surface missile, above, has a range of 700 miles and a speed of 650 m.p.h. Jet-powered, with self-contained guidance, it will replace the Matador. The Air Force SM-73 Fairchild Goose, below, is a ground-launched diversionary missile that will be used to decoy enemy air defenses from our strategic bombers and missiles.

The new Lockheed 37-foot-long X-7 missile below was developed to test the new powerful ramjet engines that will propel the Air Force's advanced interceptor weapons. The new vehicle can carry four different types of engines and complex camera instrumentation. It has underwing boosters to permit ground as well as air launch and is recovered by parachute.



Defense Highlights: Monthly Review and Outlook

• **Defense Reorganization.**—After months of acrimonious discussions among officials of the Administration, Congress and the armed forces all act outwardly pleased over the Defense Department Reorganization Bill as signed. It is the result of many compromises and is packed with uncertainties that will require administrative action to clarify.

"Legalized insubordination" and "legalized bottlenecks" remain in force, so that service Secretaries and the Joint Chiefs cannot be by-passed or completely ignored. The authority of the Secretary of Defense is reaffirmed, the Joint Chiefs of Staff are strengthened. The assignment of all operating forces to unified commands is encouraged.

The Defense Secretary can reassign or abolish statutory functions of any service provided Congress does not disapprove within seventy days.

Each service is reduced from four to three Assistant Secretaries and only seven Assistant Secretaries of Defense are authorized. However a Director of Defense Research and Engineering is established who will supervise all research and engineering activities and have direct control over centrally managed programs. As this will eliminate one of the present Assistant Secretaries of Defense, only seven remain—but a reduction in the burdensome bureaucratic structure of the Pentagon does not seem probable.

The authorization of the Secretary of Defense to consolidate common service or supply activities seems harmless but can be loaded with headaches for military commanders forced to use supplies or weapons not suited to their particular needs and procured by people not versed in military logistics problems. Unnoticed by press and commentators, this can be one of the most vital—weaponswise—of all the changes.

There are more changes authorized in the bill that clear up some conflicts. However, none of the clauses seems to offer any great savings in time or money, and it will be interesting to see if the first report of the Defense Department to Congress will list many economies.

• **Not Enough Research.**—Air Force research and development are inadequate. A special committee headed by H. Guyford Stever, of the Massachusetts Institute of Technology, reports insufficient and inconsistent funding, excessive administrative "controls" (red tape and interference) over engineers and scientists, and too small a profit margin allowed on research contracts.

The committee pointed out that recent increases in the budget for research failed to cover increases in direct costs and overhead. Thus the level of effort in research is decreasing rather than building up. Although the study was made at the request of Gen. T. D. White, Air Force Chief of Staff, the findings are of great interest to all services and to Congress.

• **New Test Stand.**—One of the facilities that our members might have an opportunity to see at the Southwest Regional Meeting of the American Ordnance Association on October 9th is the 1,000,000-pound-thrust rocket test stand under construction at the White Sands Missile Range. The new structure is being prepared by the enlargement of an earlier 300,000-pound-thrust stand. The maximum thrust that can be handled presently is 500,000 pounds on a test stand completed in 1950.

• **New Naval Weapons.**—Chief of the Navy Bureau of Ordnance, Rear Adm. P. D. Stroop, reports that money spent on new weapons has increased from 20 to 60 per cent of the budget since fiscal 1954. Next year, with lightweight picket-boat depth charges and new antisubmarine torpedoes going into production, and continuing improvements in missiles and rockets, almost 70 per cent of BuOrd's budget will be required for ultramodern armaments. The admiral also said that 70 per cent of the procurement and production budget and over half of the research and development funds go to private industry.

• **Jamproof Missile.**—The Air Force's Mace is an interesting second-generation missile that is beginning to replace the early Matador—both developments of the Martin Company. Outstanding features of this weapon over its predecessor are: jamproof guidance systems either by automatic terrain recognition or inertial devices with selectivity through interchangeable nose cones, and greater weight and range.

The automatic terrain recognition and navigation system (Atran) will give great accuracy at low altitudes; the inertial guidance system is more effective for high-altitude approach. Experimental and training versions of Mace are equipped with parachute packs for recovery. (See photo on p. 246.)

• **Nuclear Rocket Propulsion.**—Soon a ground-based experimental nuclear rocket propulsion engine will undergo tests at the Atomic Energy Commission's Nevada proving ground. After three years of research, the scientists of Los Alamos Laboratory are ready to test their theory in connection with Project Rover, a program to develop a nuclear engine for rocket propulsion. Such a unit is expected to give four times the specific impulse of conventional rocket fuels. This first test vehicle is aptly named Kiwi—a strange bird that can't fly.

• **Research for Nuclear Power.**—Rear Adm. Lewis L. Strauss, in his new office as Special Assistant to the President for the Atoms for Peace Program, explained why the United States leads in nuclear-power research for peace. He emphasized that we have fewer producing atomic power plants in

operation because our abundant sources of conventional energy give cheaper power. European fuel sources on the other hand are so limited that nuclear power is competitive. However, in research in all possible forms of nuclear power reactors, this country definitely sets the pace for the world.

Admiral Strauss also reiterated his reasons for the undiminished need to continue testing nuclear weapons as the only means to ensure that we maintain the adequacy of our deterrent power.

• **Five-Stage Test Rocket.**—In a new use for rockets the Air Force is preparing a 5-stage vehicle, named Jason, for monitoring nuclear blasts at Eniwetok. The first stages will consist of an Honest John followed by two stages of Nike boosters, a Thiokol Recruit, and finally a Thiokol T55 to carry the instrumentation. Expected altitude—up to 500 miles.

• **Defense Spending.**—Pentagon comptrollers report that defense spending picked up in May and will continue its steady rise throughout the remainder of the year. This upswing includes both major procurement and production items and general supplies such as food and petroleum products. The average monthly rate is predicted to be about $1.4 billion.

• **Progress in Fusion.**—Power from fusion of hydrogen advanced another notch when scientists at the University of California Radiation Laboratory achieved a temperature of 10 million degrees centigrade. One hundred million degrees is the calculated temperature necessary for useful controllable fusion. Atomic Energy Commissioner John F. Floberg testified, "We have advanced farther than lots of people think."

• **State of Readiness.**—The importance of the Sixth Fleet and the Tactical Air Command was highlighted by the speed with which they arrived on the scene when Lebanon appealed for help from the United States. Over forty ships of Sixth Fleet components—Striking, Amphibious, and Service Forces, including the missile cruiser BOSTON—arrived within hours off Beirut to land supplies and provide air cover for the three Marine battalions.

Two battalions normally are assigned to this fleet—the third one happened to be in the process of relieving when trouble flared.

Tactical Air Command readiness was exemplified when a composite strike force of fighters, light bombers, and tankers, organized under Nineteenth Air Force Headquarters, flew into Adana, Turkey, from various United States bases. The combat aircraft of this force, like those of the Sixth Fleet, can use atomic weapons.

Also immediately rushed overseas was a fleet of TAC's C-124 troop carriers which then lifted over 1,700 Airborne troops of the 24th Division from Germany to the Middle East. The latter movement had been rehearsed in part when conditions in Lebanon first became unsettled.

• **Manpower.**—The rude turn of events appears to have changed manpower planning. In spite of many danger spots throughout the world, Regular, Reserve, and National Guard forces were in for reductions that would decrease our military strength, especially our ability to fill the gaps left by forces committed to unforeseen trouble areas. Now the present manpower levels are expected to be maintained.

• **Antitank Missiles.**—The Army's antitank missile, Dart, has plenty of foreign competition in the French Nord SS-10, English Vickers 891, and Swiss Cobra. The latest development is Cobra 4, with a guided shaped charge and visual control like all the others but with greater range and accuracy. The SS-10, developed before Dart, is being used experimentally by our Seventh Army in Germany while awaiting deliveries of Dart.

• **Space Weapons Briefs.**—The record distance covered by the two Air Force Thor-Able missile shots and the great amount of excellent data collected went unnoticed in excitement over the mice lost in the nose cones.

The explosion of the first fully engined test of Atlas was reportedly due to malfunction of one of the gyroscopes.

Although Explorer IV will continue to orbit for four to five years, it "disappeared" from the headlines in less than four days.

The recovery of the second full-size Jupiter nose cone doubly confirmed that Army Ordnance had solved the reentry problem.

• **British Defense Establishment.**—British Prime Minister Harold MacMillan announced changes in his country's defense establishment. Defense Minister Duncan Sandys previously had been authorized to reorganize the armed forces as required by strategic needs and the economic situation. Now the Defense Minister's increased powers have been made permanent and a Defense Staff and a Defense Board established to assist him.

The Chief of the Defense Staff will be Minister Sandys' direct military adviser. The Defense Board will consist of the First Lord of the Admiralty; the Secretaries of State for War and Air and the Minister of Supply; the Chiefs of the Defense Staff, Naval Staff, Imperial General Staff and Air Staff; the Defense Ministry's permanent secretary and his chief scientist.

• **Army Missile Demonstration.**—An impressive demonstration of Army Ordnance missile firings was held at the White Sands Missile Range on July 1st. Maj. Gen. W. E. Laidlaw, commanding general there, and his capable assistants "threw the book" at the distinguished assemblage of legislators, press, science, and industry which had been invited to have a look-see.

Participating and taking appropriate bows were the heads of companies engaged with Army Ordnance in producing these new devices. Technical personnel of the companies took part in conducting the firings, signifying the close teamwork between industry and Army Ordnance. There was never a more convincing and reassuring demonstration of the team's capability of developing modern guided missiles. Congratulations are in order all around.

The Ordnance District System

An Editorial

ONE of the most effective devices for the advancement of military armament preparedness in all its phases is the system of District Offices of the Army Ordnance Corps. Headquarters of each is located in a strategic industrial center. These agencies serve as direct contacts with science and industry.

One of their prime rôles, both in peace and in war, is that of listening posts for new sources of weapons supply, new trends in development and production, and new industrial organizations and people that may be depended upon to produce satisfactorily.

In time of emergency they become primarily procurement establishments for the placement and administration of Army Ordnance contracts. They represent decentralized operations in the best sense of the word, and they are peculiar to our American way of weapons production, *i.e.*, dependence upon industry to do the job right and fast!

The genesis of the Army Ordnance District System dates back to the days when the Ordnance program of World War I got under way. Maj. Gen. C. C. Williams, then Chief of Army Ordnance, inaugurated the system and called upon the late Guy E. Tripp, then chairman of Westinghouse Electric & Manufacturing Company, to establish the system.

The Williams-Tripp leadership enlisted the help of well-known industrialists throughout the Nation, thirteen of whom were selected to serve as District Chiefs in each of thirteen selected localities—the confines of the Districts being set to conform to the areas of the Federal Reserve Bank System. Each of these gentlemen, serving on a volunteer basis, assisted the professional military personnel in the discovery of sources of supply of armament and in the breaking of production bottlenecks which prevailed so generally.

At war's end in 1919 this decentralized system of operation had proved of such value that it was continued in peacetime on a much reduced scale and has existed without interruption since.

IN time of war, the complement of personnel required in the Districts grows in proportion to the workload, and usually consists in the main of a corps of inspectors assigned to specific commercial production under contract. In time of peace and of slack matériel needs, the size of the District headquarters complement heretofore has shrunk to small numbers but adequate to carry on the functions of contact, listening post, search for new developments and new sources of supply.

For more than twenty-five years, during the period between the First and Second World Wars, the normal complement of an Army Ordnance District was small, led by a volunteer civilian District Chief, aided by a Regular officer of the Ordnance Corps as deputy, and a small contingent of clerical and administrative assistants. The cost of maintaining the system was infinitesimal.

THAT the system over the years has produced amazing results is the general testimony of all who have observed it closely and studied its effects. Immediately following the Second World War, the Ordnance Association, at the request of the then Chief of Army Ordnance, Maj. Gen. Everett Hughes, appointed a special board to study and recommend as to the future of the system.

The board was under the chairmanship of the late Frank B. Bell, of Pittsburgh, Pa., an outstanding industrialist and patriot, then president of the Edgewater Steel Company and a lifelong devotee of industrial management and quality product. He gave many years of his busy life to the study of Ordnance needs and of the means for obtaining them.

Associated with Mr. Bell as members of the A.O.A. Ordnance District Board were other leading industrialists including Russell E. Gardner, Jr., St. Louis; C. Jared Ingersoll, Philadelphia; H. L. Pierson, Detroit; John Slezak, Chicago; Whitney Stone, New York; and Dean Witter, San Francisco. All were experienced in Ordnance-Industry relationships.

These qualified leaders who composed the Bell Board were unanimous in their recommendations that the system be continued, believing that while the character and required quantities of weapons would change from time to time the basic principle of close contact with industry was essential and could best be performed on the local level, far from the red tape and obstruction constantly existing at the seat of government. This document, known as the Bell Board Report (published in the January-February 1947 issue of this magazine), charted a course for the continuation of the system on its original pattern as of exceptional advantage to the Army and the Defense Establishment.

Now the time has come to reduce the cost of operation of the system, and this is a worthy goal. But two schools of thought exist as to the methods of accomplishing this objective. One is to reduce the number of Districts; the other is to keep the long-established number but to streamline their functions appropriate to the needs of the times.

Indeed, a third school of thought is now on the scene: it would combine all military, naval, and air procurement districts—as though armament is of the same breed as breakfast food, or airplanes, or locomotives. The fallacy of such immature thinking is clear. The A.O.A. Bell Board Report has set the standard as far as the Ordnance Association is concerned.

In recent months three of the most valued and successful Ordnance Districts have been discontinued as such—those at Pittsburgh, Pa., the steel capital of the world; Rochester, N. Y., the optical metropolis; and Springfield, Mass., a small arms and small-arms-ammunition center of the Nation.

ASSOCIATION AFFAIRS

Admiral Monroe Addresses Anniversary Dinner Meeting of San Francisco Post

The San Francisco Post celebrated its thirty-fifth anniversary with a dinner meeting on May 22nd at the Fairmont Hotel, San Francisco, with 500 members in attendance. It was "Navy Night," and Rear Adm. Jack P. Monroe, commander of the new National Pacific Missile Range, spoke on the subject, "Missiles over the Pacific."

Post President W. E. Waste, executive vice-president of Bechtel Corporation, presented the following Post officials and guests at the speakers' table: Col. John M. Stark, commander of the San Francisco Ordnance District, Post secretary-treasurer; L. Eugene Root, vice-president and general manager, Missile Systems Division, Lockheed Aircraft Corporation, newly named Post director; Rear Adm. D. W. Ryan, representing the Twelfth Naval District; W. E. Butts, immediate past president of the Post and president of General Metals Corporation; Maj. Gen. R. L. Howze, deputy commanding general, Sixth United States Army; E. Finley Carter, director, Stanford Research Institute, Post vice-president; J. M. Hait, Post past president and executive vice-president of Food Machinery and Chemical Corporation; W. E. Hoard, regional manager, Western Gear Corporation, Post director; Jean Witter, general partner of Dean Witter & Company, Post director; and Col. H. H. Heuer, chaplain, Sixth United States Army.

Mr. Waste briefly reviewed the history of the San Francisco Post and the importance of membership in the American Ordnance Association. He noted the growing scientific and industrial importance of the Bay Area in the national defense and announced a campaign for 2,000 Post members and a revitalized Post program. He said Jack L. Ashby, Post vice-president and vice-president and general manager of Kaiser Steel Corporation, would head the membership drive. Program planning, he said, would be undertaken by Mr. Carter, Mr. Witter, and Elmer R. Peterson, vice-president of Standard Oil Company of California.

Mr. Waste praised the administration of Mr. Butts, 1957 Post president, and presented him with the American Ordnance Association's Certificate of Appreciation for his efforts in the national defense.

In his remarks Admiral Monroe said the Pacific Missile Range, with headquarters at the Naval Air Missile Test Center, Point Mugu, Calif., which he also commands, would be America's third—supplementing those at Cape Canaveral, Fla., and at White Sands, N. Mex.

Control center for the range is being established at the Naval Missile Facility at Point Arguello, Calif., west of Point Mugu. The range is to have its basic capability next January, the admiral said, and will be used by all the services for firing missiles and training crews. The geographic position will permit launching of satellites in true polar orbit, with only empty ocean for missile stages to fall upon.

Admiral Monroe voiced the opinion that guided missiles would replace manned aircraft and guns only when they could do a better job. Meantime, for the "cold war," America must maintain conventional forces with rapid mobility to cope with "brush fires."

He said no nation on earth could pursue both all-out missile and satellite programs. The Communists, he said, knew we would not use our missiles for aggression and thus could concentrate on satellites—with great propaganda effect. He believed the United States was ahead in missile development and holding its own in military and economic posture.

Left to right: Post President W. E. Waste; Maj. Gen. R. L. Howze, Deputy Commander, 6th Army; Maj. Gen. Sory Smith, Commander, 4th Air Force; Rear Adm. D. W. Ryan, 12th Naval District; Rear Adm. J. P. Monroe, Commander, Pacific Missile Range.

Fuze Committee Holds Spring Meeting At Diamond Ordnance Fuze Laboratories

The spring meeting of the A.O.A. Fuze Committee of the Bomb and Artillery Ammunition Division, was held at the U. S. Army Diamond Ordnance Fuze Laboratories, National Bureau of Standards, Washington, D. C., on May 27th.

The Committee was greeted by Committee Chairman J. E. Burke and Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), A.O.A. staff director for technical operations, and Lieut. Col. J. A. Ulrich, commanding officer of the Diamond Ordnance Fuze Laboratories, welcomed the Committee members.

P. E. Landis gave an introductory talk on proximity fuzing, explaining the principles, operation, and design characteristics of several typical projectile, rocket, and bomb fuzes.

J. H. Campagna (DOFL) explained some of the problems of the air-target and surface-target proximity action, several typical solutions, and some of the results obtained to date; Maj. C. D. Thurston, Air Force Special Weapons Center, gave a brief description of some of the

actual fuzing systems employed in current Air Force missiles; A. Nunes-Vais (Picatinny Arsenal) discussed the fuzing for Hawk and Dart guided missiles; L. E. Richtmyer (DOFL) gave a description of the fuzing systems for mines; Frank Luke (Frankford Arsenal) discussed a mechanical time fuze system; J. J. Redmond (Naval Ordnance Laboratory), presented a paper on new techniques and field artillery proximity fuzing; and T. A. Prugh (DOFL) discussed microminiaturization.

Chairman Burke concluded the meeting with some remarks about Committee business. After adjournment the members and guests attended a reception and dinner at the Shoreham Hotel.

20-mm. Fuze Committee Of Small Arms And Small Arms Ammunition Division Meets

A meeting of the 20-mm. Fuze Committee of the Small Arms and Small Arms Ammunition Division of American Ordnance Association was held at Frankford Arsenal, Philadelphia, Pa., on May 12th.

The meeting was called to order by Chairman Edward J. Lauenstein. He presented Brig. Gen. James A. Richardson, III, commanding officer of the arsenal, who gave a brief history of Frankford. At its inception in 1814 the arsenal dealt with small-arms ammunition consisting of flints, musket balls, and black powder, and it was very fitting that in the year 1958 a meeting of the Small Arms and Small Arms Ammunition Division was held at the arsenal that had pioneered the small-arms field.

J. Piskorski, of Lake City Arsenal, presented a paper on the production engineering of the M505 series fuze.

A report was given by W. P. Taylor, of the Industrial Engineering Division of Lake City Arsenal, on "Surface Roughness Measurement on M505E1 Fuze Metal Parts."

Ellis Read, of Frankford Arsenal, reviewed the history of the M505 type fuze and tests which had been made, and advised the Committee that Frankford will publish the results of these tests which can be obtained through ASTIA.

Los Angeles Post Visits Flight Test Center At Edwards Air Force Base

The Los Angeles Post spring meeting on Saturday, May 17th, was in the form of a field trip to the Flight Test Center at Edwards Air Force Base, Calif.

Under the leadership of Post President Whitley C. Collins, a large bus cavalcade of members and guests, numbering over 1,000, including many youngsters, arrived at the Test Center at 9:00 a.m. where they were greeted by Brig. Gen. Marcus F. Cooper, commander of the Flight Test Center. The general welcomed all hands and introduced members of his staff of pilots, technicians, and engineers who explained their part in flight testing at Edwards.

The briefing was followed by a motor tour of the maintenance shops, test shops, and laboratories of the installation.

In the afternoon, following a "chuck wagon lunch" brought in by a Los Angeles caterer, the members explored a large static display of modern aircraft and guided missiles. Later, when the party was seated in the grandstand, a thrilling demonstration of supersonic aircraft under test was presented. Many of the latest types and some not yet in production were put through their paces.

The trip was voted a great success as it enabled many of the Los Angeles members involved in aircraft development and production to see their products in action at close range.

Florida Post Inaugurates New A.O.A. Chapter At Patrick Air Force Base

The Patrick Chapter of the American Ordnance Association was inaugurated at Patrick Air Force Base, Fla., under the auspices of the Florida Post on Wednesday, May 28th. From Post headquarters at Eglin Air Force Base, Fla., came Col. Eugene Romig, Post president, accompanied by Lieut. Col. Marvin E. Kay and Lieut. Col. Ben Young (membership chairman). National A.O.A. headquarters was represented by Maj. Gen. E. P. Mechling and Capt. J. M. P. Wright.

Ira Ross, director, Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y., guest of honor, joined the visitors and new Chapter officials for dinner preceding the meeting at the Officers' Club.

A broad representation of officers and engineers attached to Patrick AFB and engineers from the cooperating missile producers gathered to assist at the inaugural ceremonies.

Col. Leonard M. Orman, who spark-plugged the new Chapter, first introduced General Mechling, who outlined the benefits and new policies of the Technical Divisions and Sections which he directs. Colonel Romig welcomed the Chapter on behalf of the Florida Post.

The gavel then was passed to Lieut. Col. E. G. Wodrich, the elected Chapter chairman, who presented the other officers: Vice Chairmen E. G. Uhl, general manager, Martin Company Orlando Plant, and W. W. Dodgson, local manager for Radiation, Inc.; Program Chairman F. W. Barnett, Radio Corporation of America; and Capt. F. L. Hafer, U. S. A. F., Chapter secretary-treasurer.

Among organizers of the Patrick Chapter are, seated left to right: Col. L. M. Orman, chairman of the organization committee; G. T. Willey; Lieut. Col. E. G. Wodrich, Chapter chairman; Standing, left to right: J. W. Downs; Capt. F. L. Hafer, Chapter secretary-treasurer; Dr. Albin W. Benson; J. F. Thompson; Fred I. Barnett, program chairman; Lieut. Comdr. J. J. Parish; M. S. Friedland; and Col. C. J. Kronauer, Jr.

Captain Wright discussed the over-all importance of the Association, read the preamble of the Association's constitution, and presented the Chapter charter to Colonel Wodrich on behalf of the national organization.

Mr. Ross spoke brilliantly on the responsibility of the scientist to give all his fellow citizens a better understanding of the startling new developments in the defense field. In such knotty areas as nuclear weapons testing, limited war, and exploration of space there are many pros and cons, half-baked views, and much

sloppy thinking. Mr. Ross believes that in these and other fields the duty of scientific and technical people is to see that others are aware of all aspects and, in research matters, point out the more worth-while projects.

The speaker closed in pointing to professional associations as a superior medium for broadening general appreciation of his subject, and particularly commended the American Ordnance Association in this regard.

Capital Cities Post Honors Cadets, Hears Gen. Mechling At Last Meeting

The Capital Cities Post closed its season with a spring meeting on Tuesday, May 20th, at Panetta's near Albany, N. Y. Members were on hand from all areas of the Capital Cities Post to welcome the guest of honor, Maj. Gen. E. P. Mechling, A. O. A. staff director for technical operations, and to honor prize-winning students from near-by universities. Post President A. M. Demont, as presiding officer, welcomed the guests and called on Arthur B. Gregg, of General Electric Company, president-elect.

Left to right: Capital Cities Post President-Elect A. B. Gregg; Maj. Gen. E. P. Mechling, guest speaker; Capt. E. Langton, U.S.N.; Cadet L. L. Edwards, R.P.I.; Cadet J. W. Stahlman, Siena College; and A. W. Demont, Post president.

Mr. Gregg expressed his appreciation for being selected president and called for a great effort on the part of the Post to increase its membership in the coming year.

The two cadets who were to receive the special Capital Cities Post award for outstanding scholarship in their R.O.T.C. units were then introduced. They were Cadet J. W. Stahlman of Siena College, and Cadet L. L. Edwards of Rensselaer Polytechnic Institute. They were to receive the Post's award and honorary membership in the A.O.A. during ceremonies at their respective colleges later in the month.

General Mechling spoke on the procedures followed by the Air Research and Development Command in achieving the optimum support of industry in the development of new weapons systems. His talk was in such interesting and instructive detail that it will be printed in a forthcoming issue of ORDNANCE. The general not only outlined the tasks of the various research centers but described the manner in which they will bring industry into the planning of new weapons systems at the earliest practicable date.

Combat and Tactical Vehicle Division Holds Fourth Annual Conference

The fourth annual conference of the Combat and Tactical Vehicle Division was held at Fort Bragg, N. C., on May 16th-17th, with Everett L. Baugh, chairman, presiding. Top-ranking engineers of American industry and the armed forces met for this 2-day secret meeting.

On the morning of May 16th the nine Technical Committees of the Division met concurrently to conduct their respective discussions involving armament, armor, engines and power trains, light tanks, medium tanks, self-propelled artillery, special-purpose vehicles, tactical vehicles, and tracks and suspensions of combat and tactical vehicles.

Technical papers were delivered by: Antony Muzicka, Watervliet Arsenal, N. Y.; Billy D. Sissom, Aberdeen Proving Ground, Md.; Henry P. George, Pittman-Dunn Laboratory, Frankford Arsenal, Philadelphia, Pa.; E. F. Blackburne, Research and Development Division, Ordnance Tank-Automotive Command, Detroit Arsenal, Center Line, Mich.; Robert L. Zouck, Aircraft Armaments, Inc., Cockeysville, Md.; Norman Macdonald, Field Service Division, Ordnance Tank-Automotive Command.

Other papers were presented by: Col. H. S. Sundt, CONARC Headquarters, Fort Monroe, Va.; Karl A. Rydquist, Cadillac-Cleveland Ordnance Plant, GMC, Cleveland, Ohio; William F. Milliken, Jr., Cornell Aëronautical Laboratory, Buffalo, N. Y.; Robert H. Freeburger, Industrial Division, Ordnance Tank-Automotive Command; Robert J. Otto, Research and Development Division, OTAC.

The Committee meetings adjourned for a noontime luncheon at the Officers' Club Annex Open Mess. After lunch, Maj. Gen. R. F. Sink welcomed all guests to the XVIII Airborne Corps and Fort Bragg.

Following General Sink's welcoming address, Committee chairmen reconvened their individual committee meetings. Afternoon technical papers were presented by: Harry V. Joyce, United States Steel Corporation, Pittsburgh, Pa.; Lawrence E. Miazga, Industrial Division, Ordnance Tank-Automotive Command; Homer E. Helm, Industrial Division, Ordnance Tank-Automotive Command; Walter Verdier, Food Machinery and Chemical Corporation, San Jose, Calif.; Col. H. S. Jablonsky, chairman, Airborne and Electronic Board, Fort Bragg; R. A. Moran, Ford Motor Company, Dearborn, Mich.

Other papers were presented by: Maj. Sheldon Hicks, Army Infantry School, Fort Benning, Ga.; Fred W. Gerow, Research and Development Division, Ordnance Tank-Automotive Command; Ellis C. Hendrickson, Pacific Car & Foundry Company, Renton, Wash.; Maj. G. J. Braun, Jr., Department of the Army, Washington, D. C.; Lieut. Col. G. L. McKee, U. S. Army Armor Board, Fort Knox, Ky.; Peter T. Garland, Industrial Division, Ordnance Tank-Automotive Command; Col. W. H. King, Jr., Ordnance Officer, Fort Bragg, N. C.; Donald L. Gibson, Food Machinery and Chemical Corporation, San Jose, Calif.; and P. H. Van Cauwenberg, Industrial Division, Ordnance Tank-Automotive Command.

The discussions following each presentation indicated the great reserve of technical knowledge and know-how possessed

by members of the various Committees.

During the evening the Division members and their guests attended a reception at the Officers' Open Mess honoring General Sink and his staff. The reception was followed by a formal dinner. Personnel at Fort Bragg, under the supervision of Capt. C. B. Watson, chief of the Visitors' Bureau, entertained all conferees after dinner with "The Fort Bragg Revue."

On May 17th, all conferees assembled at the Post Main Theater for the presentation of a very interesting morning agenda. Chairman Baugh greeted the conferees on behalf of Deputy Chairman Chester C. Utz, Chrysler Motor Car Division, Detroit, Mich.; Division Secretary James M. Heyne, assistant chief engineer, Cadillac-Cleveland Ordnance Plant, GMC, Cleveland, Ohio; and himself. He then introduced Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), A.O.A. staff director for technical operations, Washington, D. C., who extended a warm welcome to industry and Ordnance from A.O.A. Headquarters. Mr. Utz has since become chairman of the Division.

Further interesting presentations were given as follows: "Combat and Tactical Vehicle Development Parameters," by Maj. Gen. Nelson M. Lynde, commanding general, Ordnance Tank-Automotive Command; "Airborne Corps Operations," by Brig. Gen. C. H. Chase, chief of staff, XVIII Airborne Corps, Fort Bragg; and "Marine Corps Tactical Vehicle Requirements," by Brig. Gen. R. D. Salmon, U. S. M. C., director, Marine Corps Landing Force Development Center, Marine Corps Schools, Quantico, Va.

Following a noontime luncheon at the Officers' Club Annex Open Mess the group was transported to observation Post Number 3 to witness artillery demonstrations including the detonation of an atomic simulator.

The program reached its climax at Sicily Drop Zone where paratroops and heavy equipment were dramatically dropped from huge C-119, C-123, and C-130 aircraft as part of the airborne demonstration. Both the artillery and airborne demonstrations were held in conjunction with Armed Forces Day ceremonies in the Fort Bragg area. Upon completion of these field exercises in the late afternoon, the conference was adjourned.

Quad Cities-Iowa Post Celebrates Armed Forces Day At Rock Island Arsenal

The Quad Cities-Iowa Post members joined with other local organizations to celebrate Armed Forces Day at a dinner meeting at Rock Island Arsenal, Rock Island, Ill., on Saturday, May 17th.

Presiding officer was Col. D. L. Hine, commanding officer of the arsenal, who called the meeting to order and introduced the distinguished members of the community who were at the head table and, in explaining the significance of Armed Forces Day, called for full support of our men in uniform on the part of the community.

Brig. Gen. William K. Ghormley, commander of the Ordnance Weapons Command, presented the guest speaker of the evening, Dr. James A. Van Allen, chairman, Department of Physics, State University of Iowa, and chairman of the IGY Committee on Scientific Uses of Earth Satellites. Dr. Van Allen gave the audience an outline of the primary problems involved in space satellite programs and discussed the field of instrumentation in some detail. He noted that, within present capabilities, one could either launch several satellites with limited instrumentation of great accuracy or pack a larger satellite with a multiplicity of instruments of less reliability in telemetering their findings.

Dr. Van Allen described the present plans of the Administration for a governing body to direct research and development in space vehicles. He noted that such a coördinating agency was most important to ensure the continued security of the United States and to keep it abreast of developments in the space age.

Blandy and Walsh Memorial Awards Presented to Midshipman And Cadet

The Adm. W. H. P. Blandy Memorial Award, a special shotgun, was presented at the U. S. Naval Academy during the awards ceremonies on June 2nd. Hon. John F. Floberg, Atomic Energy Commission member and a life member of the A. O. A., made the presentation to Midshipman Joseph Michael Sendek, First Class, who stood first in the study of practical naval ordnance. Midshipman Sendek, of Winber, Pa., is now commissioned ensign, U.S.N., and is serving as a summer instructor at the Academy.

The James L. Walsh Memorial Award, a sporting rifle, was won by Cadet Charles C. Hansult, who graduated first in his class in ordnance at the United States Military Academy. The prize was presented by Lieut. Gen. Garrison H. Davidson, Superintendent of the Academy, at the awards parade on Sunday, June 1st. Cadet Hansult, of Tampa, Fla., has been commissioned a second lieutenant in the Air Force.

Hon. John F. Floberg, Atomic Energy Commissioner, presents Blandy Memorial Award to Midshipman Joseph M. Sendek.

Lieut. Gen. G. H. Davidson, Military Academy Superintendent, presents Walsh Memorial Award to Cadet Charles C. Hansult.

Far East Post Assembles Two Hundred Members To Hear Japan's Ordnance Chief

The Far East Post held a gala summer meeting on June 25th at the U. S. Army General Depot, Sagami, Japan. Over 200 members assembled to greet the distinguished American and Japanese guests.

Post President Robert J. Hageman, as presiding officer and toastmaster, called

on Lawrence Martin, past Post president, to present a life membership in the Far East Post to Brig. Gen. Horace F. Bigelow. In replying, General Bigelow expressed his pleasure in serving the Far East Post and regret that he was to leave soon for duty in the Office of the Chief of Ordnance, Washington, D. C. Mr. Hageman then presented the Association's Certificate of Appreciation to Mr. Martin for his masterful organization and leadership of the Post for the past two years.

Mr. Martin after thanking his fellow members for their support, turned the tables on the toastmaster by announcing that Mr. Hageman had just been presented the Department of the Army Sustained Superior Performance Award that included a check for $300.

The guest of honor, Maj. Gen. Iwao Ikegami, Chief of Ordnance Section, Japan Defense Agency, spoke on postwar efforts in Japanese weapons progress. The general traced the history of Japanese ordnance activities from immediate postwar days, when all industrial capabilities in Japan had been destroyed, through the period of U. S. support, to the present period when Japanese industry can once more provide the majority of ordnance support required by Japan's Self-Defense Forces.

He briefly touched on some of the difficulties presently facing Japan in self-support, among which were budgetary limitations and general technical problems, further outlining corrective measures which are being instituted in overcoming these difficulties. General Ikegami expressed the conviction that Japan will be able to continue on the road to self-support in maintaining its status side by side with other free nations.

Other distinguished guests were Lieut. Gen. Emerson L. Cummings, commanding general, U. S. Army, Japan; Lieut. Gen. Haruji Kan, president, Japan Ordnance Association; Col. John M. Cone, Ordnance Officer, U. S. Army, Japan; Col. Leonard E. Engeman, commanding officer, U. S. Army General Depot, Sagami, Japan; Col. Floyd G. Pratt, MAAG-Japan, Ordnance adviser.

Two Meetings Necessary To Accommodate Crowds Of Cumberland Valley Members

Announcement of the Cumberland Valley Post spring meeting was greeted with such great interest that it was necessary to conduct the program on two days, a week apart. On both May 21st and May 28th, more than sixty members assembled at the plant of the Landis Tool Company in Chambersburg, Pa.

At the luncheon meeting, Post President William H. Strauss welcomed the guests and introduced Col. William F. Rader, commanding officer, Letterkenny Ordnance Depot, and a vice-president of the Post. Colonel Rader's theme was that in view of national uncertainty as to whether this country will need conventional weapons or guided missiles in the next war, Army Ordnance was preparing to be strong in both areas.

Comdr. James S. Spore, Naval Supply Center, Mechanicsburg, Pa., elaborated on this problem and explained that the Navy's effort was to maintain a fluid offense-defense in depth.

R. E. Price, vice-president of Landis Tool Company, welcomed the guests to his plant and described the operations therein and their relation to weapons production, explaining that the outstanding capability of his organization was extreme accuracy in grinding techniques necessary for close-tolerance equipment.

Instrument Precision Ball Bearing Committee Meets In New York City

A meeting of the Instrument Precision Ball Bearing Committee of the Fire Control Instrument Division was held at the Engineers' Club in New York City on April 16th.

Ralph L. Goetzenberger, Division chairman, announced that J. P. Gillilan, New Departure Division, GMC, would replace the recently deceased F. Eric Ericson as chairman of the Instrument Precision Ball Bearing Committee. R. C. Seeburger, Hughes Aircraft Company, and A. N. Daniels, New Hampshire Ball Bearings, Inc., were appointed deputy chairmen of the Western and Eastern Divisions, respectively. Mr. Gillilan then took the chair.

Mr. Seeburger gave a brief résumé of the progress of the West Coast group's activities and the methods used in handling their symposium meeting. The proceedings of the West Coast symposium were printed in the July 1958 issue of Logistics.

The chairman then discussed the pressing need for adherence to standards for ball bearings. He strongly urged that attention be given to stopping the constant development of new specific sizes, types, variations, and specifications without legislating against progress.

He noted that even the twelve basic newly standardized sizes of miniature range bearings could readily multiply into 24,000 variations or more by the time that flange, shield, material, fit, preload, and loading groove variations were applied. Various opinions were voiced as to ways and means of combating this trend.

It appeared that bearing makers are least able to slow a demand for new and different bearings and specifications. Mr. Seeburger suggested that perhaps the inception of flanged bearing types was a mistake since snap rings are quite suitable for many applications.

A. Hochman, of the U. S. Navy Material Catalog Office, Brooklyn, N. Y., emphasized the problem he has in cataloging many more variations, largely due to the reluctance on the part of the bearing people in giving data which would simplify the problem.

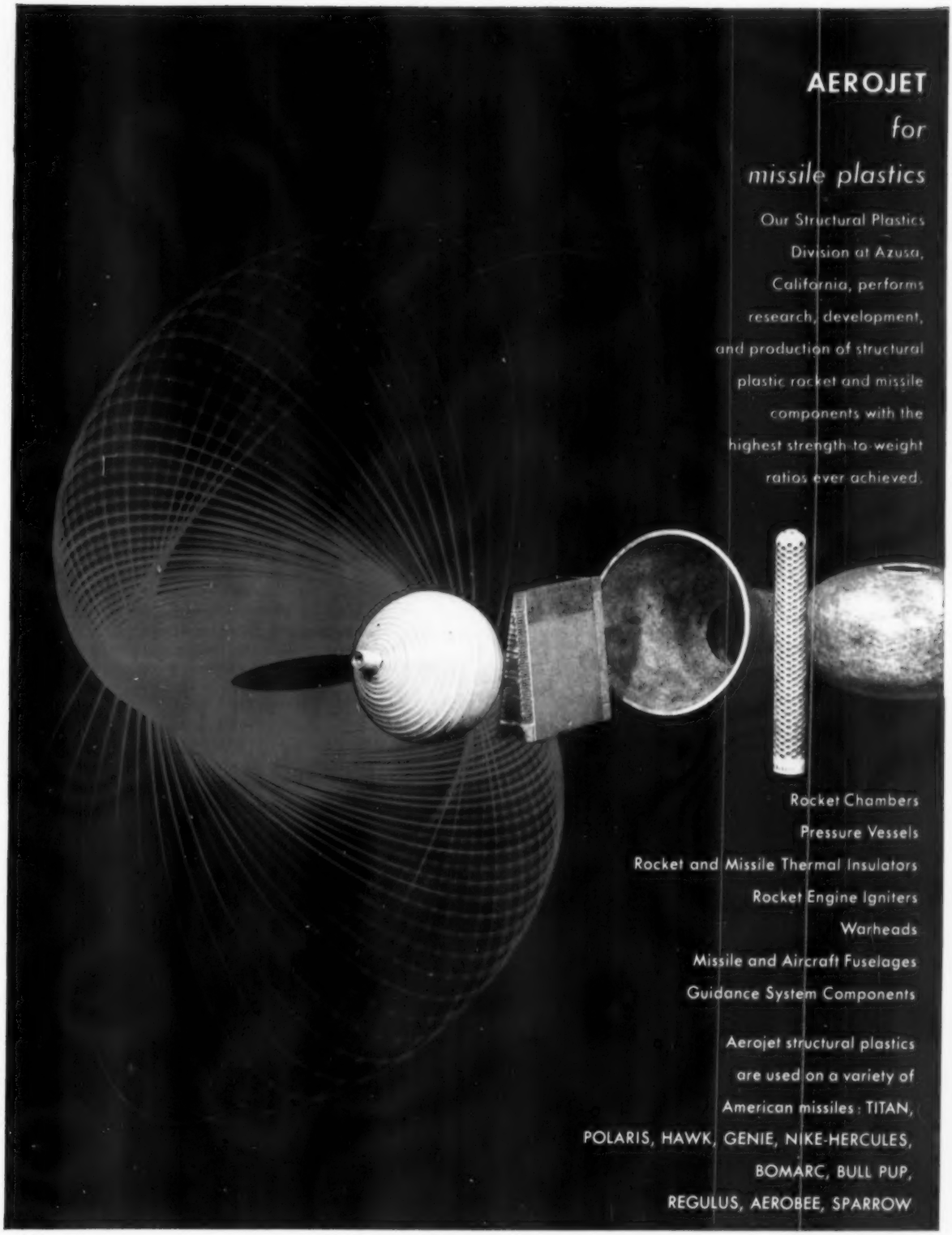
J. G. Weir, U. S. Naval Avionics Facility, Indianapolis, Ind., voiced the opinion that many standardization problems "boil down" to a lack of unification in the attitude of the services.

T. E. Rounds, Barden Corporation, Danbury, Conn., discussed the development and the present status of the proposed American Standard B3.10, and stated that it was presented at the International Standards Organization meeting in Naples in May-June of this year. He also stated that the American Standards Association would soon ballot on the existing fourth draft and that this standard would be approved by the A.S.A., at least.

F. V. Johnson, General Electric Company, Schenectady, N. Y., chairman of the Subcommittee on Torque and Vibration, discussed the status of torque. He reported that the MIL-STD-206 is now in the process of final coördination with using services and should be issued within six months. Essentially, all details meet the recommendation of the Subcommittee on Torque and Vibration.

W. E. Crowl, WADC, Wright-Patterson Air Force Base, Dayton, Ohio, stated that units at WADC and Naval Avionics-Indianapolis are now available for part-time correlation work.

It was reported that there seems to be little present need to spend much time on the study of new vibration test equipment. While bearing producers indicated that noise problems existed a few years ago, it is felt that these problems largely have been solved. However, several new types of vibration test equipment have been made available to bearing producers. The chairman requested that the Subcommittee on Torque and Vibration prepare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a list of questions to be sent out for survey purposes by the main Committee on the torque-vibration problem.

Mr. Goetzenberger announced that tentative plans have been made for a meeting of the Committee to be held at Wright-Patterson Air Force Base early in the fall to see at first hand the latest Air Force equipment of special interest to Committee members.

Chattanooga Chapter Of Tennessee Valley Post Inaugurated On June 11th

The Chattanooga Chapter of the Tennessee Valley Post became the fifty-fifth geographic unit of the A.O.A. at an inaugural meeting on Wednesday, June 11th, at Chattanooga, Tenn. This makes the sixth Association branch in the "family tree" of the Birmingham Post. This patriarch of Posts gave territory and assistance to the Louisiana Post, from which stemmed the New Orleans Post; then helped establish the Florida Post, which recently launched the Patrick Chapter. Now, the Tennessee Valley Post, originally the Huntsville Chapter, has organized the Chattanooga Chapter just six months after it was chartered as a Post.

The inaugural meeting was held at the Fairyland Club on Lookout Mountain. A lively representation from the Tennessee Valley Post had journeyed from Huntsville, Ala., with Post President M. F. Rankin, to help the Chattanooga members inaugurate their Chapter. This group included Walter Wiesman and T. D. Johnson, Post vice-presidents, and Spec Searcy, Mayor of Huntsville.

Guest of honor, Maj. Gen. John A. Barclay, commanding general, Army Ballistic Missile Agency, flew in from the missile center with Col. Calvin A. Heath, chief, Industrial Division, Army Ballistic Missile Agency, the guest speaker.

Lawrence Skelly, vice-president, the Wheland Company, newly elected Chapter chairman who led in organizing the group, introduced the other officers: William B. Bunn, Combustion Engineering, Inc., Chattanooga, and Earl E. Cline, Sr., Ernest Holmes Company, Chattanooga, vice-chairmen; A. F. Richardson, American National Bank, Chattanooga, program chairman; and H. D. Torok, Ross-Meehan Foundries, Chattanooga, membership chairman.

Capt. J. M. P. Wright, of A.O.A. Headquarters, recounted the aims and purposes of the Association, read the preamble to its constitution, and presented the charter to Mr. Skelly.

Admiral Richardson, as toastmaster, introduced the distinguished guests—General Barclay, Mayor Searcy, Mr. Rankin, and the guest speaker, Colonel Heath.

The colonel discussed industry's participation in the Army's ballistic missile program. He presented the little-known fact that 83 to 94 per cent of the budget for the Redstone, Jupiter, and Pershing missiles goes to industry. Yet, he emphasized that Army Ordnance retains close control of missile design concepts through its agency's scientists, engineers, and combat-experienced officers to ensure continuity of know-how.

Colonel Heath also outlined the many jumps in improved commercial products that have accrued through the demands for quality control, efficient design, and automatic operation in missile production.

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AAINC. MODEL 2830
MISS-DISTANCE MEASURING SYSTEM
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Electronic Components Group Meets At U. S. Army Signal Engineering Laboratory

The Electronic Components Committee of the Association held a one-day meeting at the U. S. Army Signal Engineering Laboratory, Fort Monmouth, N. J., on April 9th.

Col. Leon J. D. Rouge, commanding officer of the Electronic Component Research Department of the laboratory, welcomed the Committee to the base. The A.O.A. response was given by Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), staff director for technical operations.

Discussion of matters pertaining to the function and operation of the Committee was then led by Committee Chairman P. S. Darnell, of Bell Telephone Laboratories, Inc.

Three papers were presented by members of the Signal Laboratory covering the following topics: "A Forward Look at Solid-State Devices," "A MASER Frequency Standard for Missiles," and "New Concepts of Micro Modules."

Following the presentation of the papers the Committee members toured the facility and then adjourned.

(Continued on p. 260)

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¶ Do you need room-temperature cleaning combined in one operation with temporary rustproofing? *See pages 12 and 14.*

¶ Do you know the advantages of *alkaline* pickling? *See page 21.*

¶ Have you compared the values of iron phosphate coating and zinc phosphate coating in preparation for painting? *See pages 22 and 25.*

¶ Can you use a cleaner that removes rust and oil at the same time; often eliminating all need for pickling? *See page 30.*

¶ Do you have trouble stripping epoxy resins, pigment residues, phosphate coatings and under-paint rust? *See page 31.*

¶ How do you clean parts that are too large to be soaked in tanks or sprayed in machines? *See page 31.*

¶ Are you getting full profit out of your finishing barrels? *See page 32.*

¶ What do you do when oversprayed paint neither floats nor sinks in your paint spray booth wash water? *See page 35.*

¶ Do you need better protection against rusting in process or in storage? *See page 37.*

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Machine cleaning methods
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Applying iron phosphate coatings in preparation for painting
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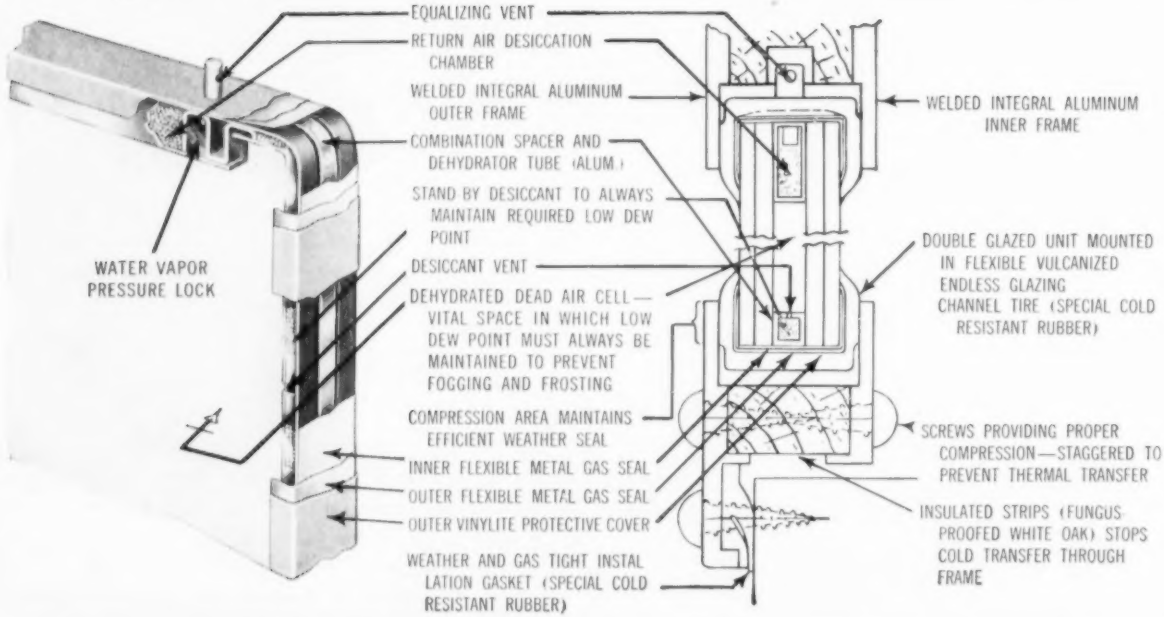
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WELDED INTEGRAL ALUMINUM OUTER FRAME
COMBINATION SPACER AND DEHYDRATOR TUBE (ALUM.)
STAND BY DESICCANT TO ALWAYS MAINTAIN REQUIRED LOW DEW POINT
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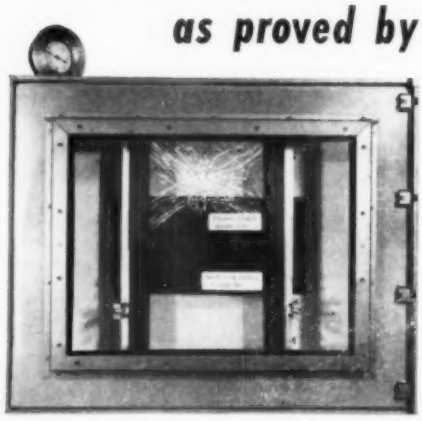

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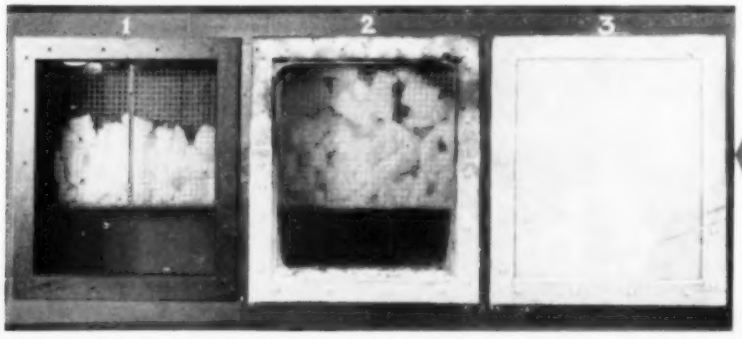

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Container Committee Holds Meeting At Naval Ammunition Depot, Red Bank, N. J.

The Container Committee of the Bomb and Artillery Ammunition Division held its fifth meeting at the Naval Ordnance Materials Handling Laboratory, Naval Ammunition Depot Earle, Red Bank, N. J., on April 30th and May 1st. Harvey C. Simms, Cleveland Container Corporation, Washington, D. C., chairman, presided.

The Committee members were welcomed to the depot by Capt. E. C. Hawk, U.S.N., commanding officer of the depot. He was followed by Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), A.O.A. staff director for technical operations.

The following papers were presented: "Ordnance Packaging for a Progressive Modern Navy," Norman A. Junker, Navy Bureau of Ordnance; "An Approach to Weapon System Packaging and Handling Problems," Robert J. Munson, Convair Division, General Dynamics Corporation; "Current and Proposed Weapon Handling Equipment and Techniques Today and Tomorrow," G. J. Geyer, Navy Bureau of Ordnance; "New Developments in Packaging Adhesives," Paul Weitz, National Starch Products, Inc.; "Tactical Packaging of Delicate Ordnance Equipment," Harold T. Decot, Craig Systems, Inc.; and "Water Emulsion Paints for Containers," E. H. Borkenhagen, Rossford Ordnance Depot.

After lunch at the depot mess hall, the group moved by bus and private car to the Naval Ordnance Materials Handling Laboratory at the waterfront where they were welcomed by Comdr. V. L. Homer.

Brief talks were made by J. E. Kelly, chief engineer; George Kalista, supervisory engineer, mechanical section; Henry Green, supervisory engineer, industrial engineering section; and Anton Harmsen, supervisory engineer, packaging section.

Following these introductory talks, the following papers were presented: "Container Testing Procedures at the Naval Ordnance Laboratory," H. F. McClellan, Naval Ordnance Laboratory; "Flexible Packaging Material in Ammunition Packaging," Howard M. Weiner, Picatinny Arsenal; "Molded Foam Styrene in Military Packaging and Materials Handling Applications," David H. Burger, Koppers Company, and Laurence E. Korwin, Ambassador Plastic and Manufacturing Company; "Molded High-Density Polyethylene for Packaging," Frank A. Connell, Polymer Chemical Division, W. R. Grace & Company; "Observations of Packaging in Ordnance Depots," Chester V. Parker, Field Service Division, Office, Chief of Army Ordnance; "Nailed Wooden Containers in Missile Packaging," Howard R. Hudson, National Wooden Box Association.

The meeting was closed with a reception and a dinner at the Molly Pitcher Hotel in Red Bank. The following day the U.S.S. SURIBACHI (AE-21) was inspected. On this day the SURIBACHI set an unofficial world's record for the offloading of ammunition when her crew moved 725 tons of ammunition in a 24-hour period.

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Fire Control Committee Discusses Problems During Meeting At White Oak, Md.

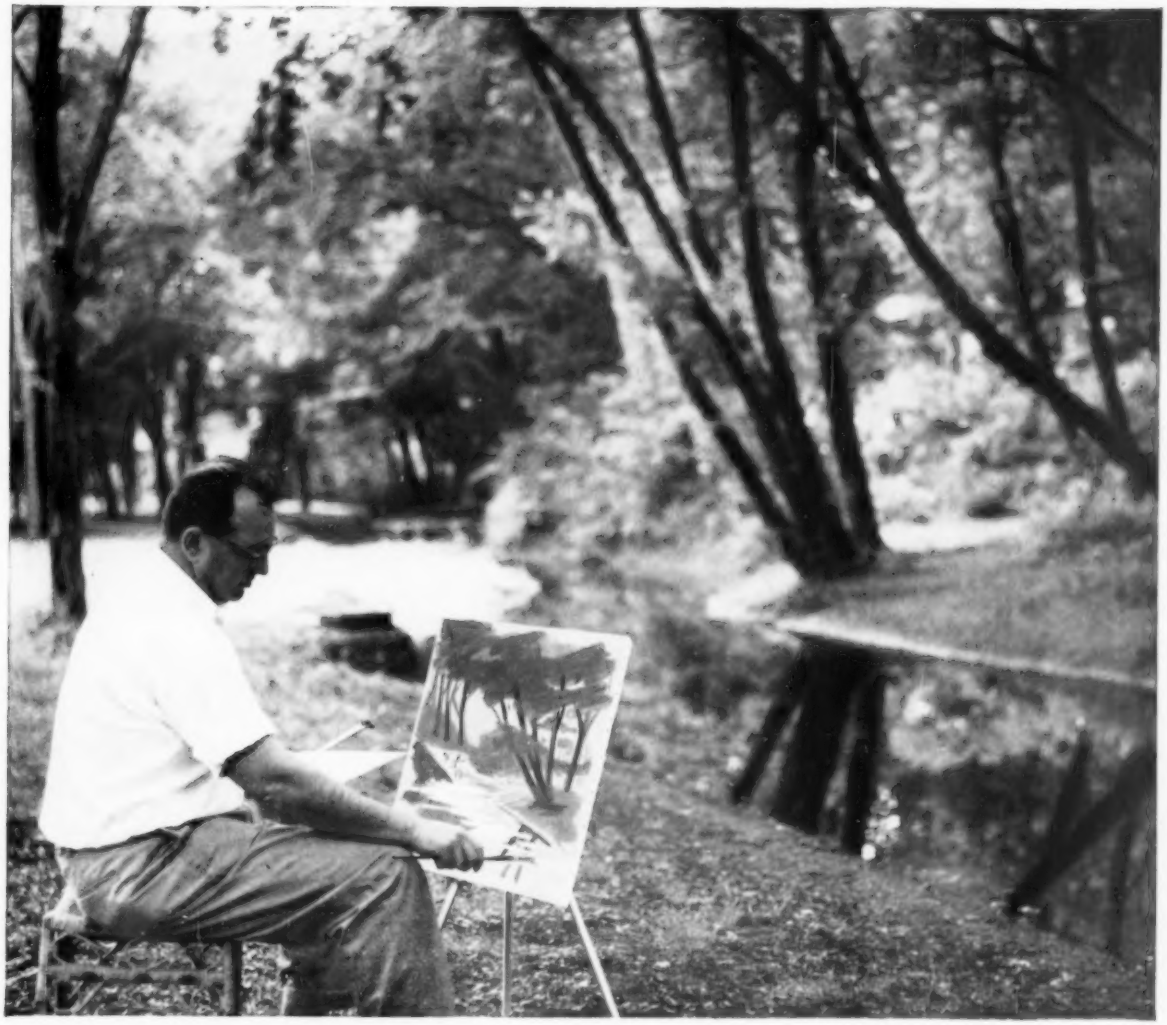
The annual meeting of the Fire Control Committee of the Underwater Ordnance Division was held at the Naval Ordnance Laboratory, White Oak, Md., on April 23rd and 24th. Alton D. Anderson of Cook Research Laboratories, the Committee chairman, directed the meeting.

Comdr. Perry Hall, Navy Bureau of Ordnance, discussed and summarized the problems submitted to the Committee by the Navy. He stated that there was immediate agreement on better than half of the Committee's suggestions to the Navy on OSTD 599. The purpose of the review of all these problems was to ascertain the position of the Committee and the work accomplished up to the present time. Commander Hall added that, in the future, Ordnance Bureau personnel who initiate problems should appear at the Committee or Subcommittee meeting where the problem will be discussed.

Paul W. Burk of the Navy Bureau of Ordnance stated that his office had tried to solve the problems relating to OSTD 600 but that this had "bogged down" because the Bureau could not return the information to the contractor in time to be of use.

Roy Koggie, Naval Ordnance Laboratory, White Oak, then presented a very informative paper on Subroc fire control problems. Melvin W. Arsove, Raytheon Manufacturing Company, Wayland, Mass., reported that the Reliability Subcommittee had met and discussed the problem of the reliability of

(*Continued on p. 264*)



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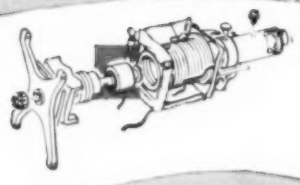
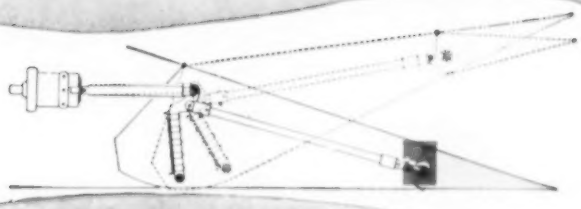


Elevator flight controls

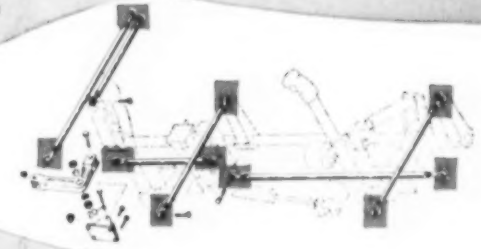


Aileron trim and servo tab control system

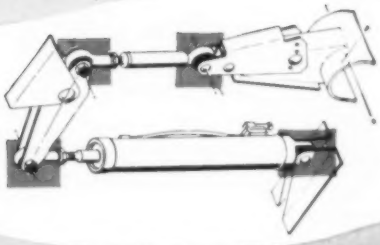
Main landing gear fulcrum and linkage

Wing flap hinge and linkage

Aileron hinge



Helicopter flight control group



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underwater fire-control equipment. An interim report of the Evaluation Subcommittee was presented by Wayne G. Shaffer, Vitro Laboratories, Silver Spring, Md., John J. Ryan, Daystrom Corporation, Woodside, N. J., submitted a report on the activities of the Records and Communications Subcommittee. Thomas D. Bryant, Librascope, Inc., Glendale, Calif., reviewed the accomplishments in the field of military specification publications.

The next meeting of the Committee is to be held at the U. S. Naval Gun Factory in Washington, D. C., in October.

Dixie Post Members Hear About Space Flight During Meeting At Fort Monroe

Dixie Post members turned out in large numbers for their summer meeting held at the Officers' Beach Club, Fort Monroe, Va., on Wednesday, July 9th. Members were on hand from throughout the Tidewater area as well as a good representation from Richmond, Va.

Following a reception, Post President George Svadeba called the gathering to order and requested Trist B. McConnell to give the invocation. Lieut. Col. E. L. Smith, U.S.A.F., a Post director, introduced the guest speaker, Maj. Stanley C. White, U.S.A.F. (M.C.), chief of the respiration section, Physiology Branch, Aeromedical Laboratory, Wright Air Development Center. Major White's subject was "Human Factor Studies for Future Systems."

In his introduction, the major made it clear that the engineers had rediscovered man and find that he will be an essential part of any space flight. He noted that for some years rapid advances in electronics made it appear that man would be too slow and fragile to be useful.

Major White explained that man can improve reliability and flexibility, maximize performance and take corrective action, and make important decisions and choices, providing he is properly adapted into the space system. The subject was made most interesting and understandable through an excellent series of slides that not only outlined the many developmental areas but showed the work in process in the field and in laboratories where future space pilots are being acclimated to the expected outer space conditions.

Major White said that the three principal problem areas were the effect of weightlessness, outer space radiation, and safe recovery. He pointed out that in spite of extensive equipment, devices, and tests, flights must be made by man before these three problems are entirely resolved. In these problems and in the work of all phases of preparing man for space travel, the major made it clear that the Army, Navy, and Air Force are all working in close coöperation.

Major White noted that for the first time in aëronautics it was expected that man would be ready for flight before all the flight equipment had been completed. On a time chart he indicated that the medical research people felt that ninety per cent of the techniques and equipment were ready for space flights up to forty-eight hours in length.

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Metal Working Lubricants Committee Holds Annual Meeting At Buffalo, N. Y.

The Metal Working Lubricants Committee of the Association held its annual meeting at the Metals Processing Division, Curtiss-Wright Corporation, Buffalo, N. Y., on May 13th. The meeting was opened by Chairman Wilbur J. Reitze. Brig. Gen. B. O. Lewis, American Ordnance Association representative, also made a short introductory talk and welcomed the members of the Committee.

The following papers were presented: "The Efficiencies of Metal Cutting," Dr. Franz Jaklitsch, Detroit Arsenal; "Short- and Long-Time Cutting Tests," George P. Witteman, Bethlehem Steel; "Machining A-286 Stainless Steel Jet Engine Turbine Wheels," Ray Baird; "Electromachining and Electrolytic Deburring," Albert E. Baker; "New Developments in Teflon Dispersions," M. E. Dougherty.

After lunch the Committee went on a tour of the Curtiss-Wright foundry, blade plant, and extrusion plant.

Underwater Ordnance Division Meets At Navy Mine Defense Laboratory, Panama City

The Underwater Ordnance Division held a highly successful spring meeting at the U. S. Navy Mine Defense Laboratory,

(*Continued on p. 268*)

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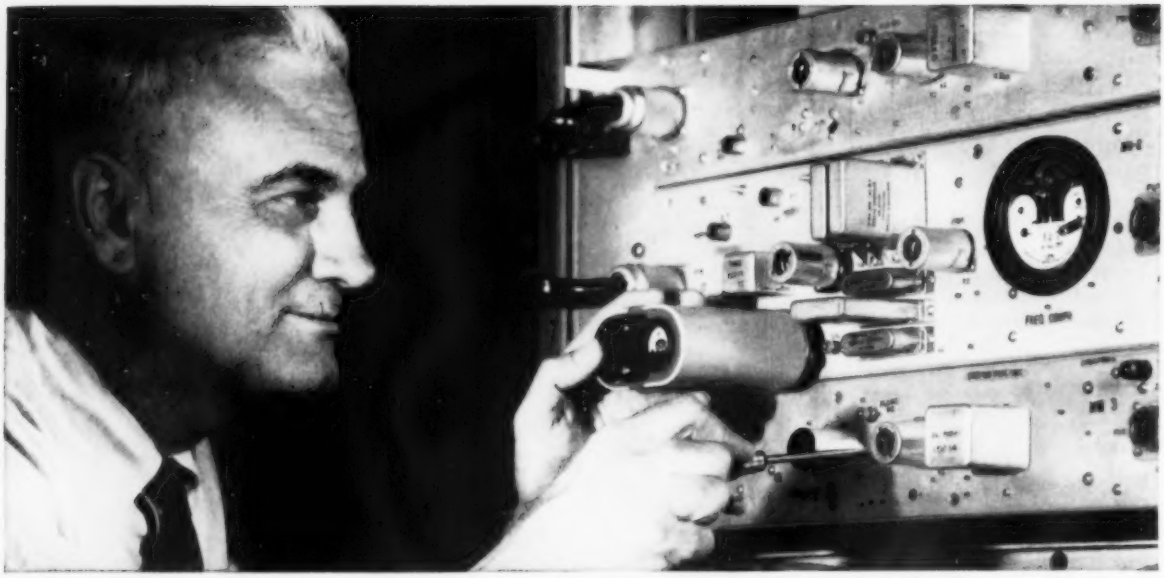
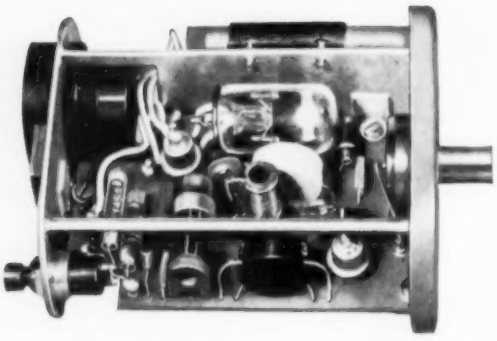
Bell Laboratories Announces Pocket-Sized Frequency Standard for Microwave Systems



Lawrence Koerner, who developed the portable frequency standard, demonstrates how the device can be plugged in at a radio relay station to supply a checking frequency. Battery-powered, the device maintains precision calibration for several months.



Inside the portable frequency standard. Four Laboratories developed devices make it possible: (1) transistor, which converts the power from a battery to radio frequency oscillations; (2) voltage reference diode, which maintains constant voltage; (3) piezoelectric crystal unit of superlative stability; (4) thermistor, which corrects for temperature variations.

Microwave radio relay systems depend critically on the accuracy of their "carrier" frequencies. At scores of relay stations along a route, carrier frequency oscillators must be checked periodically against a signal from a precise standard.

In the past, the maintenance man has had to obtain his checking frequency by picking up a standard radio signal from a government station. This operation takes time—and requires elaborate equipment.

With a new *portable* frequency standard developed by Bell Laboratories engineers, the job is much simplified. To check an oscillator, the portable standard is plugged in, and a button is pressed. In seconds, it supplies a checking frequency accurate to one part in a million.

Until now, such precision in a frequency standard has been obtainable only in a laboratory. The new portable standard makes it available for routine use in the Bell System. First use of the standard will be to maintain frequency control in a new microwave system for telephone and TV, now under development at Bell Laboratories.

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Panama City, Fla., on March 19th and 20th. F. D. Peltier presided at the meeting in the absence of Adm. A. G. Noble, the Division chairman.

Mr. Peltier reviewed the program and then introduced the Divisional host, Capt. R. K. Anderson, U.S.N., commanding officer of the Mine Defense Laboratory, who gave a comprehensive and most enlightening review of the laboratory's history, its accomplishments, and its future goals. Following this address, individual Committee meetings were held.

The second general session was devoted to reports by A. D. Anderson, chairman of the Fire Control Committee; W. G. Shaffer, chairman of the Test and Evaluation Subcommittee; M. W. Arsove, chairman of the Subcommittee on Reliability; and T. D. Bryant, acting chairman of the Records and Communications Subcommittee.

Dr. G. R. Tatum, chairman of the Torpedo Committee, announced that his group had submitted two final reports and three interim reports.

V. M. Setterholm, Committee secretary, reviewed the following reports:

Design Disclosure.—Work on this problem is continuing. A tentative conclusion reached by the ad hoc panel is to recommend that design disclosure information be filed on microfilm and electric accounting machine card records.

Development to Production Transition.—The final report of the ad hoc panel considering this problem has been received.

Environmental Specifications for Torpedoes.—The final report is being prepared for submission at the fall meeting.

Simulator Testing versus Proof Ranging of Torpedoes.—A final report is being prepared for submission at the fall Division meeting.

Repair Assemblies versus Repair Parts for Torpedoes.—A final problem report has been submitted. The gist of this report is that unit subassemblies should replace individual spare parts.

Mr. Peltier reviewed the activity of the ad hoc committee considering the problem of "value engineering"; that is, "those particular efforts in engineering related to cost reduction." He stated that the committee had held monthly meetings to study the problem and that it was recommending the modification of Bureau of Ordnance contracts to provide for a 60-40 split of the savings effected by value engineering.

Under this arrangement the contractor would realize a bonus amounting to forty per cent of the cost reduction effected through his value engineering program. Mr. Peltier hastened to point out that this committee recommendation is not compatible with existing Bureau of Ordnance regulations. The study of value engineering by the committee is continuing.

The chairman then introduced Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), staff director for technical operations, who complimented the Division and its members for their excellent work. He suggested that the Underwater Ordnance Division could well serve as a pattern for other A.O.A. Technical Divisions to follow. General Mechling announced that the December dinner meeting of the A.O.A. would be preceded by a technical seminar featuring papers on the value of scientific research.

Surface Preservation Group Discusses Various Coatings At New York City Meeting

The twenty-third meeting of the Association's Surface Preservation Committee was held in New York City on March 4, 1958. Committee Chairman E. A. Stockbower presided and in his opening remarks discussed organic coatings such as paint, inorganic or nonmetallic coatings, metallic or electrodeposited coatings, and suppliers in the equipment field for the application of these coatings to products. He also pointed up the need for better controlling specifications, with emphasis on the performance of coatings.

J. J. Kelley, Glidden Paint Company, presented industry's view of paint specifications and noted five points representing what Army Ordnance wants from industry.

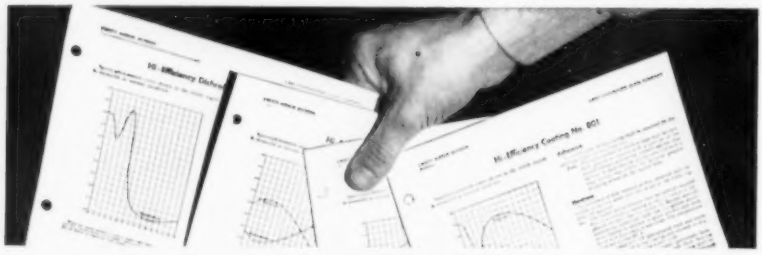
Samuel Goldberg discussed the MIL-C-5541-A military specifications of chemical films and chemical film materials for aluminum and aluminum alloys.

M. B. Rossa reported on the latest activities of the industrial group of the Phosphate Coating Subcommittee. The joint meeting of industry representatives and advisers of the Surface Preservation Committee also was reported by Mr. Rossa.

Harold F. Davidson commented on MIL-P-16232-B from the Bureau of Ordnance.

Walter M. Kisner, Springfield Armory, Springfield, Mass., gave a talk on how to use the Springfield test in evaluating and testing painted surfaces. H. L. Ammlung gave comments on the industry view of paint specifications. Eugene Kelley, Frankford Arsenal, Philadelphia, Pa., discussed coatings for ammunition cases.

(*Continued on p. 272*)



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- Beam Splitting Dichroic Filters
- Metallic Electrically Conducting Coatings
- Transparent Electrically Conducting Coatings
- Beam Splitters or Dichroic Mirrors (with transparent electrically conducting coatings)
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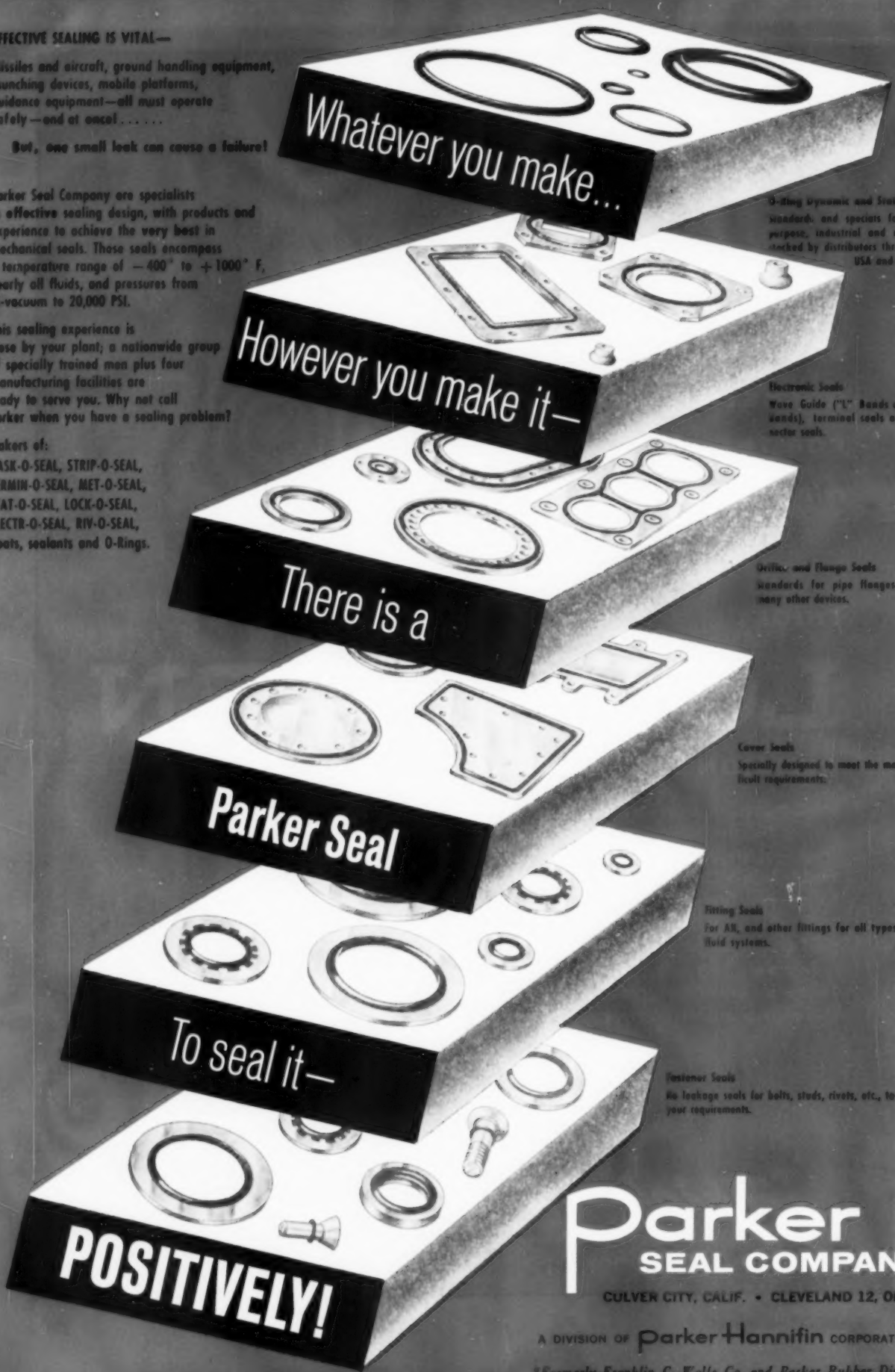

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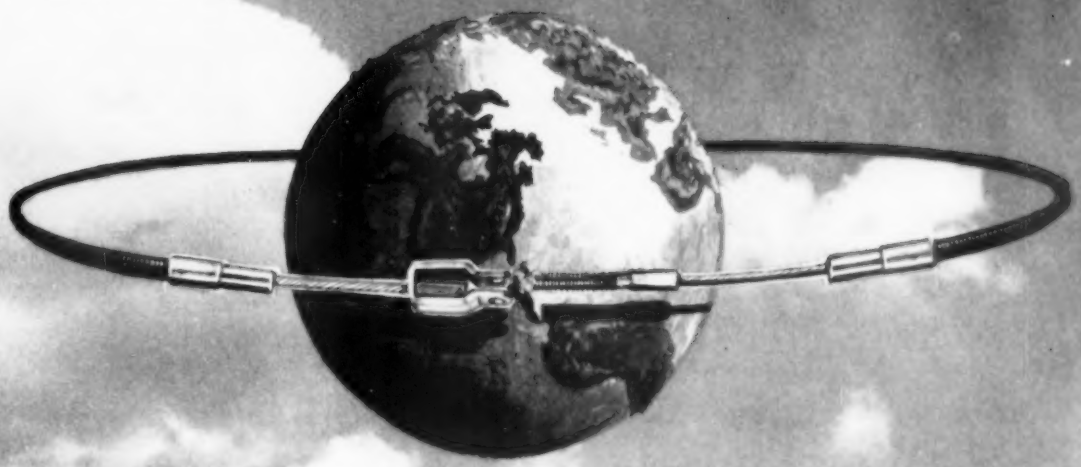

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More Ordnance R.O.T.C. Honor Cadets Receive A.O.A. Keys

Each year the honor Ordnance cadets in the R.O.T.C. units in colleges throughout the country are awarded the American Ordnance Association Scholarship Key and a year's membership in the Association. A number of such awards were published in the July-August issue of ORDNANCE. The following awards were made recently to the students mentioned below at the following institutions:

University of California, Berkeley.—Cadet Maj. Robert M. Farnam, San Mateo, Calif., is a Distinguished Military Student and vice-president of Sigma Alpha Epsilon fraternity. Upon graduation in June 1959 he will be commissioned in the Ordnance Corps.

Georgia Institute of Technology.—Cadet George K. McFarland, Birmingham, Ala., was graduated with a bachelor of mechanical engineering degree. He was a member of Phi Eta Sigma, Pi Tau Sigma, Phi Kappa Phi, Tau Beta Pi, and president of Briacrean Society. A Distinguished Military Graduate, Cadet McFarland attended summer camp at Fort Belvoir and Aberdeen Proving Ground and will report for active duty in January 1959.

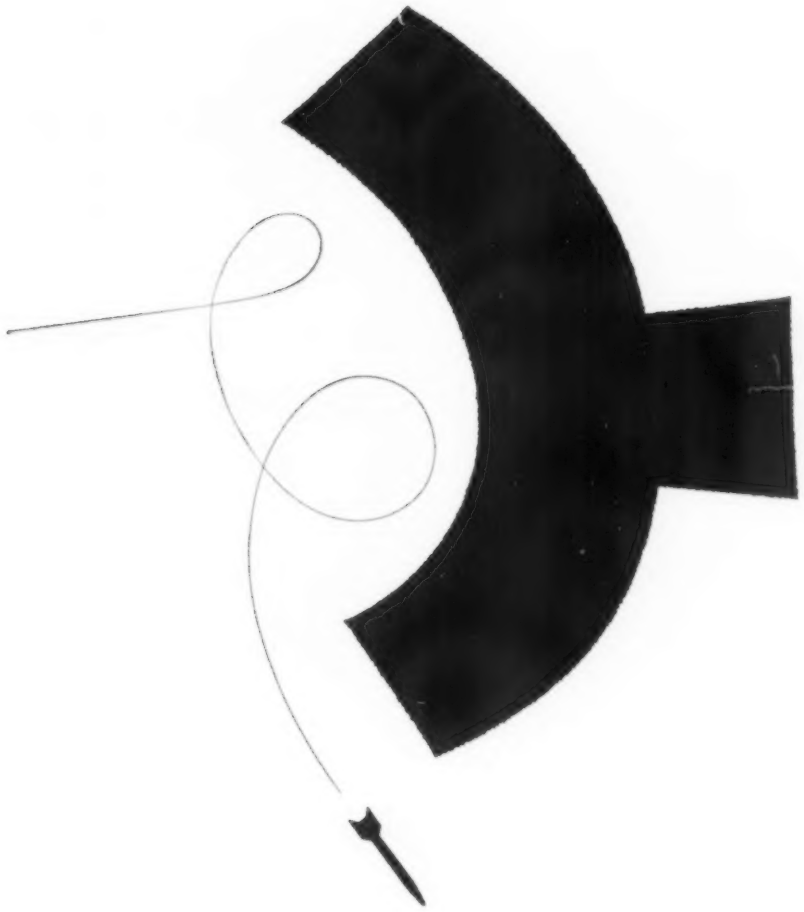
R. M. Brown G. K. McFarland R. M. Farnam

Lehigh University.—Cadet Maj. Walter Charles Pijawka, Philadelphia, Pa., received a B. S. degree in mechanical engineering. Active in football and lacrosse, he was elected to the following honorary societies: Tau Beta Pi, Pi Tau Sigma, Brown Key, and Scabbard and Blade. Presently he is a design and development engineer with General Electric Company.

Michigan State University.—Cadet Lieut. Col. Keith P. Brown, Lansing, Mich., a Distinguished Military Graduate, majored in electrical engineering. He was vice-president of the Scabbard and Blade Society and was commissioned a second lieutenant in the Ordnance Corps.

University of Minnesota.—Cadet 1st Lieut. Richard M. Brown, Hutchinson, Minn., majored in mechanical engineering and business. A Distinguished Military Student, he will be commissioned in Ordnance in March 1959. (*Contd. on p. 274*)

L. E. Hayden G. F. Dose A. O. Pittenger, Jr.



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The answers are found in secret devices and systems called "countermeasures" – designed to make missiles miss.

Electronic countermeasures. Other kinds, too

Many brilliant minds are working on the problem – including top scientists and engineers at ITT who have been researching, devising, inventing . . . for more than 15 years. Today, no less than 156 engineers at one ITT laboratory alone are working on countermeasures and nothing else.

This much can be told. A number of countermeasures exist today. Others are being perfected. Still others are being started from scratch – to be ready for whatever tomorrow may bring.

Many tools – many skills

Many tools are being used – radar, infrared, chemicals, others. Many skills are required – in physics, metallurgy, astronautics, as well as electronics. And thousands of ITT technicians and artisans are working in these fields.

This is one of the big assignments the Department of Defense has asked ITT to tackle. Guiding and controlling our missiles is another. Testing and launching them, too, and building communications between missile facilities.

The Air Force has even turned over to ITT the all-important job of operating and maintaining the Distant Early Warning radar network in the Arctic, (the "DEW LINE").

Perhaps the missiles will never come. *But if they do*—countermeasures will be needed to make them miss. ITT is working day and night to make sure the countermeasures will be ready.

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Seattle University.—Cadet Maj. Santos E. Contreras was graduated in June and was commissioned a second lieutenant in the Ordnance Corps.

Stanford University.—Cadet Maj. Arthur O. Pittenger, Jr., Indianapolis, Ind., was graduated in June and was commander of the drill team. He plans a career in Ordnance.

University of Tennessee.—Cadet Maj. Edward D. Black, Knoxville, Tenn., is a senior in industrial management and has been designated as a Distinguished Military Student.

University of Toledo.—Cadet Capt. Gene F. Dose, Waterville, Ohio, has been active in various fields. He was a member of Scabbard and Blade Society, Pershing Rifles, American Institute of Chemical Engineers, Tau Beta Pi, Presbyterian Club, and Theta Chi. Cadet Dose will be graduated in January 1959 and will be commissioned in the Ordnance Corps.

Virginia Polytechnic Institute.—Cadet Capt. Leland E. Hayden, Annandale, Va., majored in electrical engineering and was active in numerous extracurricular affairs. Among these were: Kappa Theta Epsilon, Scabbard and Blade, Tau Beta Pi, Eta Kappa Nu, Y.M.C.A., American Institute of Electrical Engineers, Institute of Radio Engineers, Society of American Military Engineers, and the cross-country varsity team. He has been commissioned in the Ordnance Corps.

The Cincinnati Post also recently awarded its own special scholarship keys to outstanding juniors. At the *University of Cincinnati*, Col. Lennard C. Sorensen, secretary-treasurer of the Post, presented the key to Cadet Alan G. Altenau, of Cincinnati, an arts and science major. At *Purdue University*, the recipient was Cadet William Hogan Lawson, of Columbus, a mechanical engineering major who has been elected to five honorary societies and stood first in a group of thirty-six Ordnance cadets.

Michigan Post Membership Committee Launches Drive With Luncheon At OTAC

The membership committee of the Michigan Post, which has brought in over thirty company memberships and hundreds of individual memberships in recent months, launched into its 1958 campaign with a special luncheon at the headquarters of Maj. Gen. Nelson M. Lynde, commanding general of the Ordnance Tank-Automotive Command, on Thursday, July 17th.

At the head table were: George W. Holley, Jr., Post membership chairman and president of Holley Carburetor Company; Mervyn Gaskin, Post vice-president and president of Taylor & Gaskin; Col. William A. Call, deputy commander, OTAC; Harry T. O'Connor, membership committee; Robert G. McLaughlin, McLouth Steel Corporation; Col. Glenn S. Finley, Jr., commanding officer, Detroit Arsenal; Frank Maxa, chairman, OTAC membership committee; and Roy W. Huber, luncheon meeting chairman.

The 220 A.O.A. members present were greeted cordially by Colonel Call, who expressed the regrets of General Lynde, who had been suddenly summoned to Washington. Colonel Call gave a complete and interesting account of the mission and activities of his command and praised the A.O.A. members for the splendid support they gave Army Ordnance in all its aspects.

A noteworthy event of the meeting was the report of Mr. Holley which further enumerated the tremendous strides made by his membership committee and outlined the plans for the coming year's campaign.

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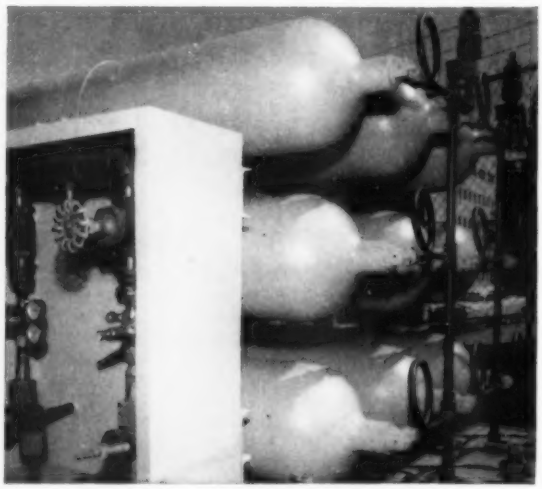
stores oxygen at 3,000 psi in National SEAMLESS Steel Cylinders



THE U. S. NAVAL HOSPITAL at San Diego, California, is using nine 47.5-cu.-ft.-capacity National Seamless Steel Cylinders to store oxygen at 3,000 psi. Each cylinder is approximately 33 feet, 9 inches long, with 18-inch O.D. x .750-inch wall.

Whatever gas you store, under whatever pressures, you can rely on USS National Seamless Steel Cylinders to provide the very ultimate in strength and dependability. Pierced from solid billets of highest-quality steel, each cylinder undergoes a severe hydrostatic test before it ever leaves the mill.

For more information on National Seamless Cylinders for gas storage, write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

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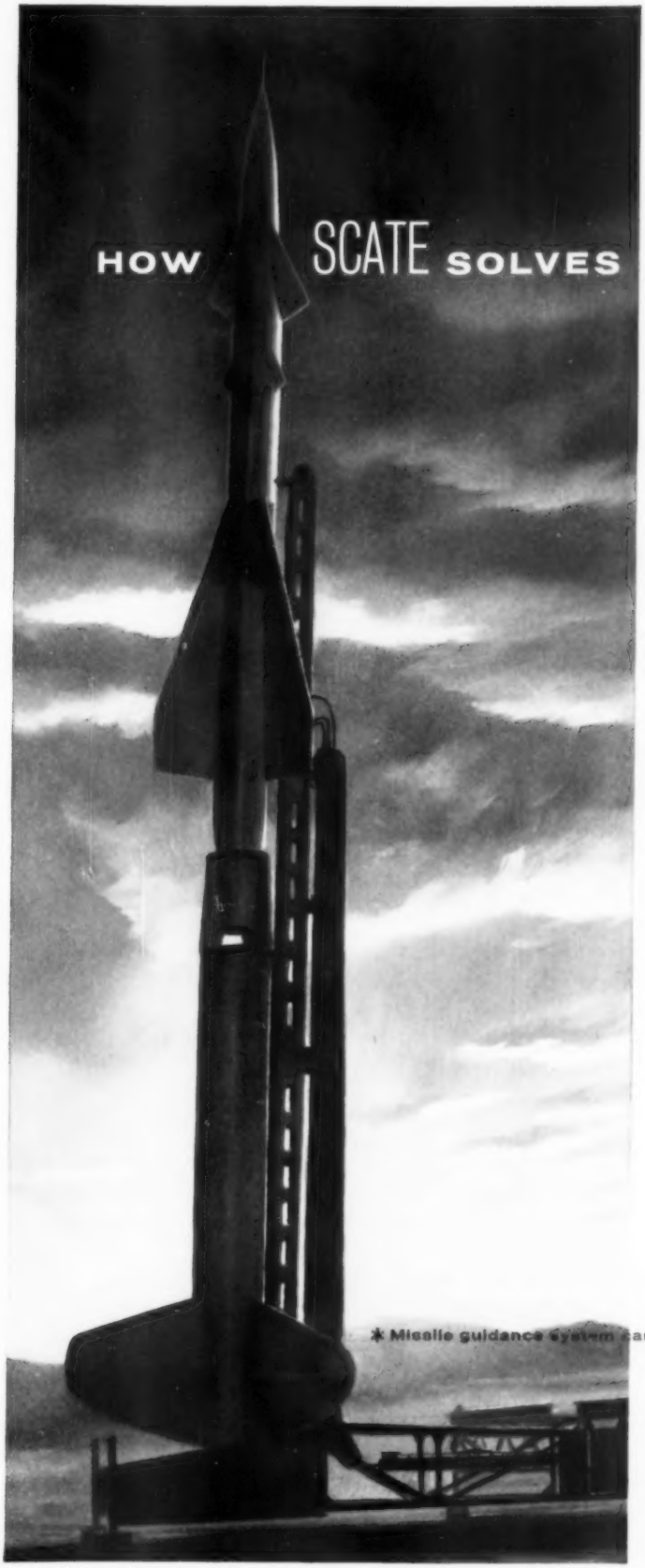
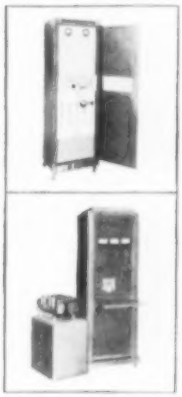


HOW SCATE SOLVES 2 BASIC PROBLEMS in testing electronic systems

Many complex electronic systems—missile guidance is a good example—may require testing that takes days by conventional methods. Yet the end function of such a system may last only a few minutes—**even seconds.**

Other systems, though less complex, must be tested in such large numbers that adequate personnel are frequently unavailable to perform tests by conventional means.

The SCATE system of automatic test equipment can solve **both** problems. It provides **self-checking** automatic testing which is **fast, flexible** and **foolproof.**



The system evaluates all important parameters of equipment under test, including:

1. RF sensitivity, center frequency, band width, power output, noise figure.
2. Audio frequency gain, band width, power output.
3. Video pulse circuitry, including pulse decoding, logic, digital comparison, pulse delays.
4. Voltage levels, DC and AC.
5. Servo response.
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Stromberg-Carlson has standing designs for all the standard components which go into a SCATE system, and is fully experienced in designing custom components which may be required in any test system.

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* Missile guidance system can be tested automatically by the SCATE system.

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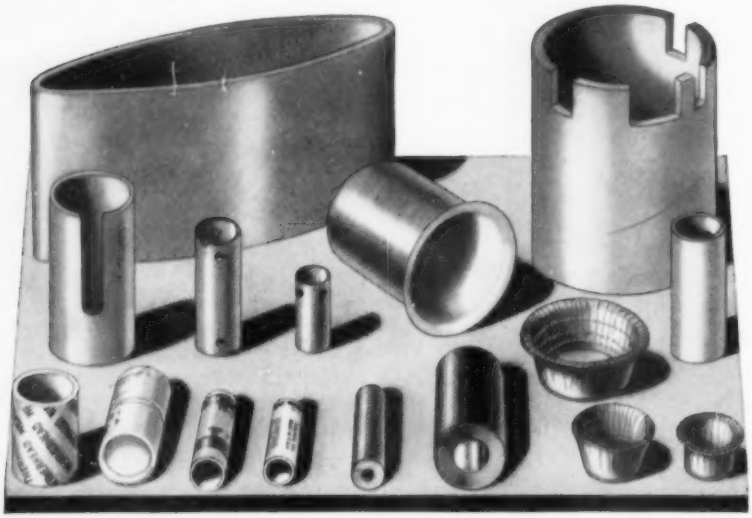

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Nebraska Post Honors Col. Norman C. Pardue At Meeting In Omaha

Many members of the Nebraska Post gathered for a luncheon meeting to honor Col. Norman C. Pardue, commanding officer of the St. Louis Ordnance District, on Thursday, July 17th. The meeting was held at the Blackstone Hotel in Omaha. Fred G. Arkoosh, Post secretary-treasurer, presided and introduced the following guests at the head table:

Dan Bradford, Post president and president of Bradford-Kennedy Company, Omaha; Robert Bernstein, Post vice-president and vice-president of Independent Metals Company, Omaha; Fred Bucholz, president of Omaha Steel Works, Omaha; Ted Hughes, a director of the Post and vice-president of Hughes Brothers Company, Seward; Robert Ammon, Post director and president of Cushman Motor Works, Lincoln; and Elmer Crawford, assistant to Colonel Pardue.

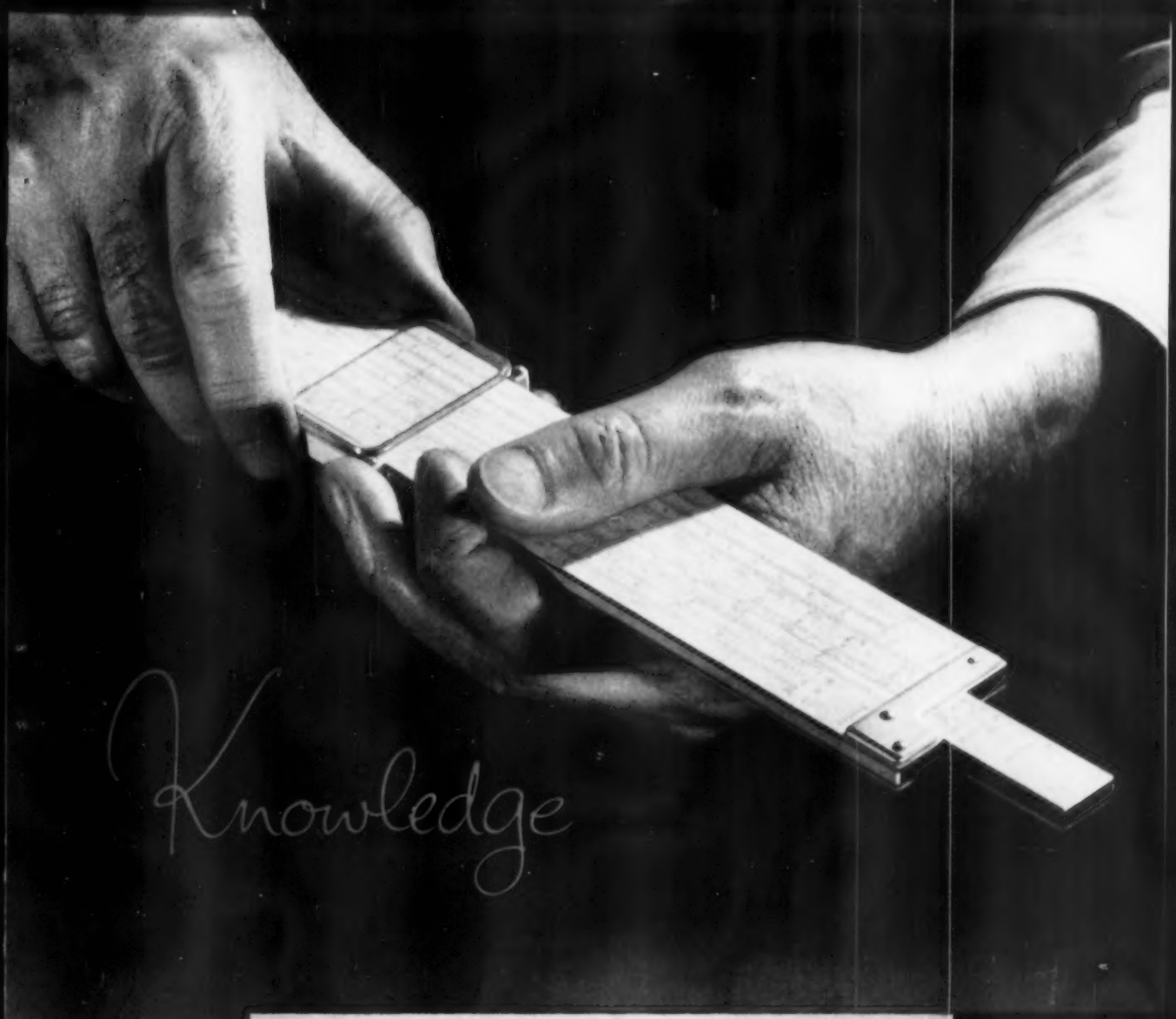
Colonel Arkoosh then introduced Colonel Pardue, who spoke about the need for increased ordnance activity in the state of Nebraska, especially in the fields of research and development of new weapons. He emphasized that the St. Louis Ordnance District was setting up a special branch to explore all possible outlets for work in missiles and missile components. The Colonel closed in expressing his pleasure at the fine turnout and expressed the hope that his talk would encourage the members to seek new talents and new ideas in the techniques of research and development.

• DR. DAVID HART, chief of the Pyrotechnics Laboratory, Picatinny Arsenal, Dover, N. J., and an active member of the Ordnance Association's Committee on Military Pyrotechnics, died at Dover, June 3, 1958. He was one of the world's most distinguished chemists in military pyrotechnics.

Educated at the College of the City of New York, Dr. Hart received his doctorate from Columbia University. Prior to his coming to Picatinny Arsenal, Dr. Hart was head of the chemistry department of Brooklyn College, Brooklyn, N. Y. The Pyrotechnics Laboratory at Picatinny was established under his guidance in 1956, and many basic and notable achievements were made which advanced pyrotechnics from an art to a science.

Dr. Hart was granted many patents on

(*Continued on p. 279*)



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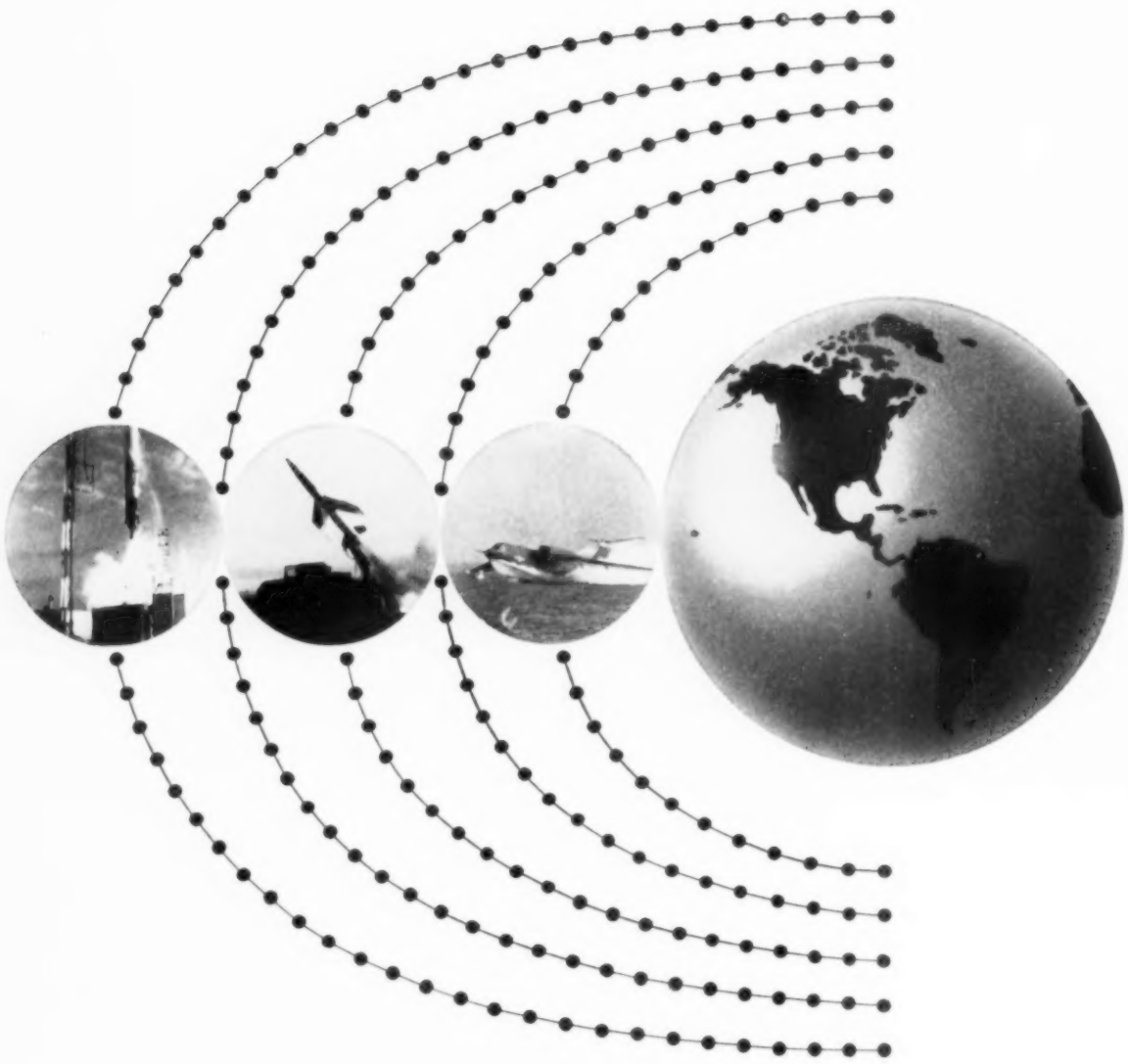

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fuze powders, photoflash powders, and other pyrotechnic compositions. He was one of the chief developers of tracking and spotting devices for rockets and ballistic missiles.

Author of numerous reports and publications, including the chapter on military pyrotechnics in the American Encyclopedia for Chemical Technology, Dr. Hart was also technical adviser on pyrotechnics to NATO search and rescue party standardization.

Long a member of the American Ordnance Association, he was consultant for the Association's Military Pyrotechnics Committee and technical adviser to the Air Standardization Coördination Committee.

A memorial fund in his honor has been started by employees of the Pyrotechnics Laboratory. Contributions will be used for the building fund of the American Chemical Society.

• **COL. CHARLES OTTO GUNTHER**, emeritus professor of mathematics and ordnance engineering at Stevens Institute of Technology, died at Short Hills, N. J., June 8, 1958. He was a nationally known ballistics expert and a charter member of the American Ordnance Association.

Born in New York City, Professor Gunther received a degree in mechanical engineering from Stevens in 1900. That same year he joined the Stevens faculty on which he served as an instructor in mathematics and assistant professor of mathematics and mechanical drawing.

He was professor and head of the Mathematics Department until 1936 when he became professor of mathematics and ordnance engineering. He retired in 1950. He received the Stevens Honor Award Medallion in 1940 for notable achievement in mathematics and ordnance.

As a major in the Army Ordnance Reserve Corps he assisted in the advanced training courses for officers at the Aberdeen Proving Ground. He was promoted to lieutenant colonel in 1931. His interest in ballistics had started in the First World War when he did outstanding work on the preparation of range tables for the Ordnance Department. He was the author of a number of books, including "Integration by Trigonometry and Imaginary Substitution," "Principles of Firearms Identification," and "Markings on Bullets and Shells Fired from Small Arms."

He was long identified with the New York Post of the Ordnance Association and seldom missed the annual meetings of the A.O.A., especially those at the Aberdeen Proving Ground where he gave much of his Ordnance service.

• **WILLIAM FLOYD BEASLEY**, well-known automotive engineer who served in

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LET him know how the Ordnance Association works for the national defense along with our armed forces . . . and how his support of the A.O.A. can really help.

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Association Affairs (Contd.)

the Army Ordnance Department for thirty-five years, died at his home in Silver Spring, Md., June 16, 1958. He was prominent throughout military and industrial circles for his leadership in the development of tanks and other combat vehicles.

Mr. Beasley entered the Ordnance Department in 1911 and participated in the design of mobile gun carriages until 1917 when he was appointed chief engineer of the automotive section of the Artillery Division. In 1942 he became chief of the Tank and Automotive Division of the Research and Development Service.

During the 1920's and 1930's, he had an important part in the proceedings of the Ordnance Technical Staff which, in those days, was a very effective agency for bringing together the requirements of the using services of the Army so that Ordnance designs might meet those needs.

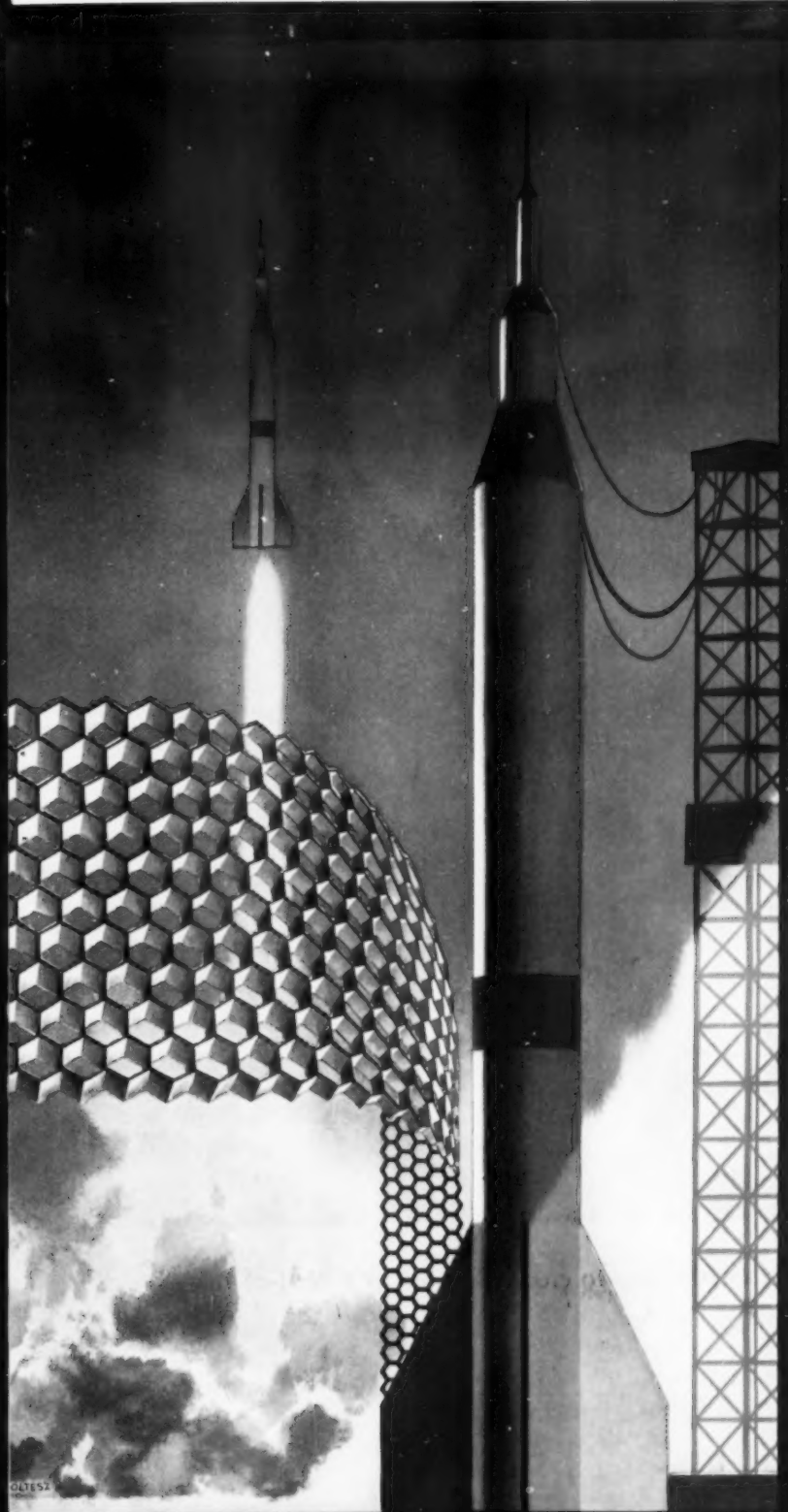
Mr. Beasley was born in Amesville, Ohio, and was graduated in engineering from Ohio University. He was a charter member of the Ordnance Association and also of its Washington Post, and during his active Ordnance service he took a leading part in the affairs of the Association both nationally and locally.

• **WILLIAM L. LUKENS**, for many years a leading ordnance engineer at Picatinny Arsenal, Dover, N. J., and a charter member of the Ordnance Association, died at Clearwater, Fla., on June 18, 1958. Prior to his retirement in 1950 he had served with distinction in the metals components department at the arsenal for twenty-three years.

Mr. Lukens was a graduate of the Drexel Institute of Technology in mechanical engineering and had been active for forty years in the design, development, and manufacture of ammunition. He served as a draftsman at the Frankford Arsenal, Philadelphia, Pa., from 1909 to 1913 and for the following fourteen years as engineer in charge of design and development in the ordnance engineering department of the Bethlehem Steel Company. He became a member of the staff at Picatinny in 1927 and served there with notable success until his retirement eight years ago.

Mr. Lukens was a member of the American Society of Mechanical Engineers and the American Society of Metals. He held many ammunition design patents and was awarded the Army Commendation for Exceptional Civilian Service. This latter honor was bestowed for outstanding contributions in the field of ammunition during World War II.

He took an active part in the operations of the Artillery Ammunition Division of the American Ordnance Association where his guidance and counsel were held in highest esteem by all his associates.



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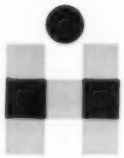

ARMS AND THE MISSION...

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NEW DEVELOPMENTS

New B-52G Mounts Missiles

The Air Force's newest bomber, the 8-jet B-52G Stratofortress missile platform will be equipped with GAM-77 air-to-ground "Hound Dog" missiles carried under each wing and designed for firing while the bomber is still hundreds of miles from the target.

The increased range of the B-52G will allow it to span oceans and return to its home base without refueling. It can fly at sustained speeds of more than 650 miles an hour and is equipped with greater safety measures, maintenance advantages, greater crew conveniences, and systems simplification.

The GAM-77, or Hound Dog, is an air-to-surface missile designed to extend the capabilities and useful life of the B-52. Power will be furnished by a Pratt & Whitney J-52 jet engine, without afterburner, carried in a pod suspended below the rear of the missile itself.

During captive flight the missile will be suspended from the B-52 on a specially designed pylon which contains monitoring and launching equipment. Once launched, the GAM-77, which will carry a nuclear warhead, will be directed to its target by guidance and control equipment.

Night Vision Device

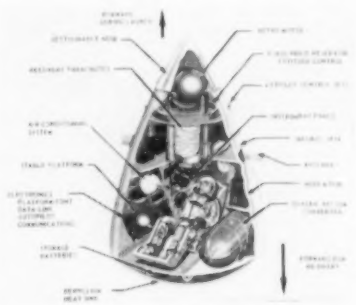
A new night vision device enabling troops to see military objectives at night with the aid of light obtained from the stars has been developed by the Army Engineer Research and Development Laboratories, Fort Belvoir, Va., and the Radio Corporation of America, Harrison, N. J. The new device is known as the "cascaded photosensitive image intensifier."

The new development, differing from other night vision devices which utilize infrared, radar, and other mediums, gathers the reflected starlight or diffused light from skyglow falling upon the objective. It then intensifies or amplifies the diffused light sufficiently to present a distinguished image. The device is free from the complexities associated with low-level light intensifier television systems and requires no source of artificial light or radiation.

Heart of the instrument is a cascaded image tube, actually two tubes working in a series and operating through an optical system which focuses the light reflected from objects in the field. The first tube acts as preamplifier for the second which in turn further amplifies or intensifies the light and presents the image on the viewing surface. The tube is powered by current at approximately 25,000 volts, furnished by a compact 6-volt battery through a system of transformers and transistors.

Manned Space Craft

A program for putting a recoverable manned space laboratory into orbit within three years was outlined recently by Northrop Aircraft, Inc., which claimed it has developed basic design criteria for



Ballistic recovery capsule.

such a laboratory to be used in preparation for U. S. military ventures into space.

The space laboratory would be a bullet-shaped capsule, approximately seven feet in diameter and ten feet long. The space traveler inside it would be strapped in a near-reclining position in order to withstand the forces of acceleration and deceleration as the vehicle takes off and later plunges back into the earth's atmosphere.

Contemporary rocket engines would boost the space laboratory into orbit. Once in orbit, it would be turned by attitude-control jets so that its blunt end faced forward. This would provide a high drag to slow the capsule as it hurtled back into the earth's atmosphere, otherwise the occupant would be crushed by the force of gravity and burned up by the intense heat generated by friction.

At a point halfway around the earth from the landing spot, reverse-thrust rockets would slow the capsule so that it would drop into an elliptical orbit whose lowest point touched earth. Action of the rocket would be controlled by a star-tracking navigation system. Between 20,000 and 30,000 feet altitude, parachutes would open to ease the capsule to the ground.

"Thinking" Machine

The concept of the first nonbiological system capable of perceiving, recognizing, and identifying its surroundings without any human training or control has been successfully demonstrated and proved by Dr. Frank Rosenblatt, research psychologist at the Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y., under contract for the Office of Naval Research at Washington, D. C.

Called "Perceptron," and closely paralleling the selective recognition or "similarity" functions of man's mind, the new concept opens up challenging possibilities of future applications which heretofore have appeared only in the realm of science fiction.

Although the pilot model of a machine designed specifically for these functions is about one year from completion, the "Perceptron" system has been effectively simulated on a conventional IBM 70 computer many times in proving its concept and practicability. It has in each case demonstrated the ability not only to "learn" what it is "shown" but also a capability of spontaneously "teaching itself" to recognize something, and then indicate what that particular something is, even though it has never "seen" it before.

Inertial Flight System

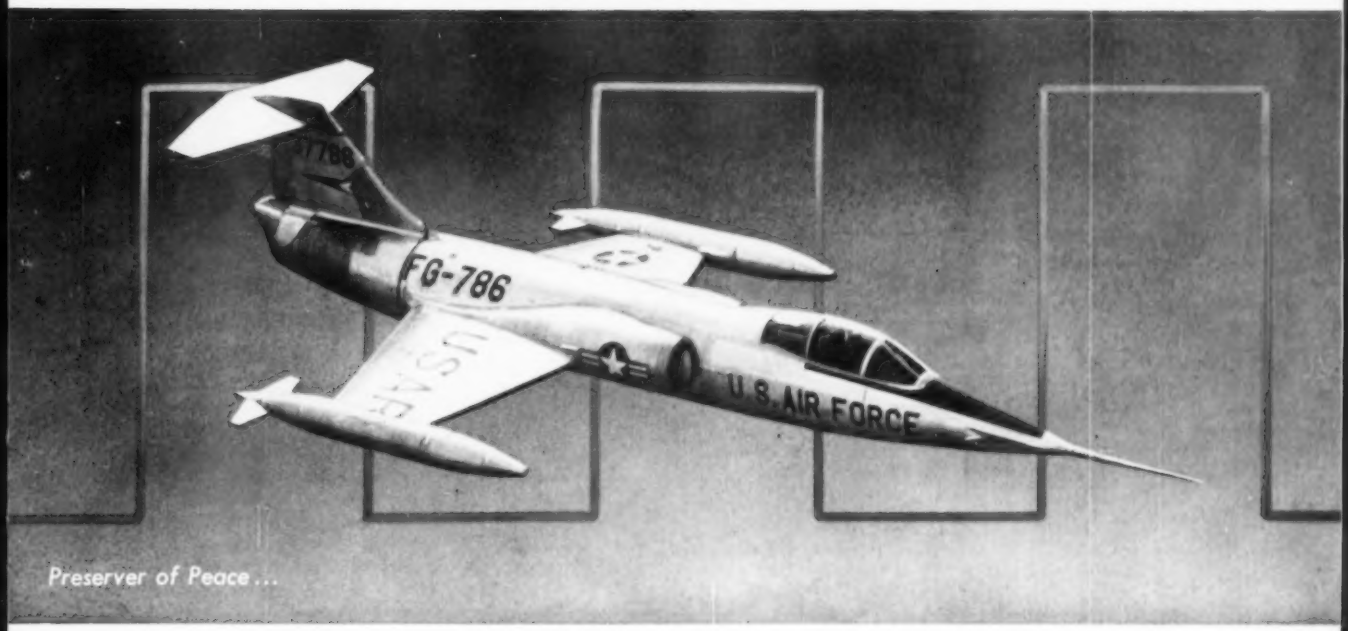
An advanced flight instrument system for the hypersonic X-15 research aircraft, developed by Sperry Gyroscope Company, has been disclosed by the National Advisory Committee for Aeronautics and the United States Air Force. The system's principal function is to help the X-15 pilot control his rocket plane to prevent it from burning up by reentering denser atmosphere too steeply, or "bouncing back" too high from too shallow a trajectory. The system also will feed electronic information into airborne recorders to chart each flight permanently.

The X-15 is under development for the Air Force by North American Aviation, Inc., for an initial flight expected next year to an altitude of more than 100 miles at a speed of about 3,600 miles an hour, or about one mile a second.

The instrument system will provide the X-15 pilot with inertial flight aids and

surface-air
time-division

DATA LINK



Developed and produced by Radio Corporation of America for the U.S. Air Force, the Time-Division Data Link system employs digital transmission for the transfer of control information between ground environments and airborne systems. The use of digital techniques of high-speed computers brings the concept of automation to the field of communications and guidance of airborne weapons systems. Applications of the system are: *ground controlled intercept, missile guidance and control, return to base, en route air traffic control, automatic landing systems, tactical support.* This new RCA development is compatible with NATO Data Transmission Specifications, and is of important significance both to military and civilian flying.

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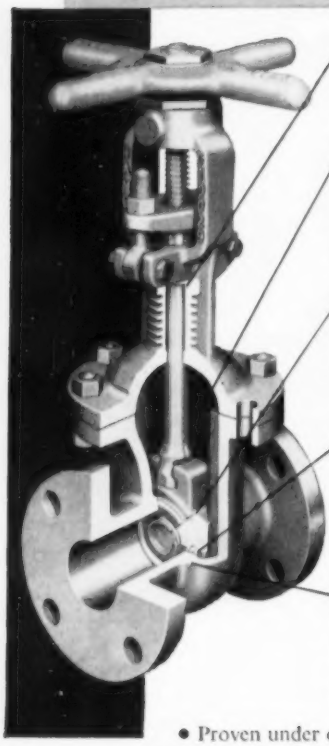

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Seal on one side vents chest to pipeline, thus preventing locked-in pressure buildups.

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Seating surfaces are precision finished for exacting metal to metal fit against seats.

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Located in one side of the wedge only, this seal compresses against valve seat forming an absolute shut-off.

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Integral design eliminates threads, welds & other objectionable surface irregularities.

• Proven under environmental field conditions, these contour engineered Gate Valves seal equally well with line flow in either direction. Seal in one side of wedge vents valve chest to pipeline preventing dangerous pressure buildup. Valves are available in various sizes in a range of metals. Write today for literature and the name of your nearest Hamer representative.

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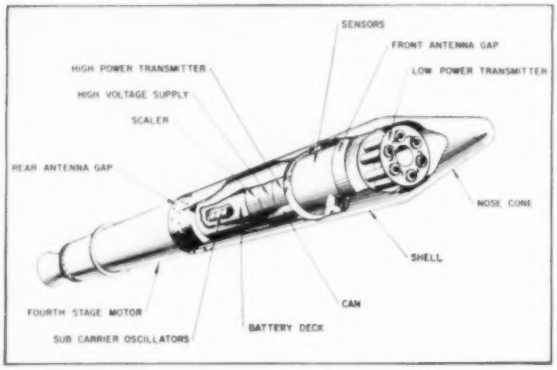
sensing devices on the trip to outer space. The system is composed of a 3-gyro stable platform which provides critical attitude, velocity, distance and altitude sensing, and a lightweight computer that digests and interprets the data. It is designed to meet space and weight problems, and it cannot be jammed during operation. It was developed to withstand accelerations in excess of ten times the force of gravity. The system may be adaptable to other forms of missile guidance and outer space experiments undertaken by the Air Force.

Army Satellite "Explorer IV"

The U. S. Army successfully launched a scientific earth satellite, Explorer IV, late in July. External cylindrical configuration of the newest satellite is identical with the earlier Explorers. Instrumentation is more advanced and specialized and is devoted to the investigation of corpuscular radiation at extreme altitudes and latitudes. Explorer IV is in a highly elliptical orbit



Power and instrument payload of Explorer IV.

and its orbital band covers most of the earth's surface. Its extremities are the 51st latitudes north and south, compared with the 35 degrees attained by Explorers I and III.

The satellite was launched by a modified Jupiter-C missile, the Army's composite reëntry test vehicle which played a major rôle in the solution of the aërodynamic reëntry heating problem associated with the Jupiter IRBM development program.

Amphibious Lighters

A contract for development of two new wheeled amphibious lighters of five and fifteen-ton payload capacities has been awarded to the Ingersoll Kalamazoo Division of Borg-Warner Corporation, Kalamazoo, Mich. Intended to replace the remaining old 2½-ton-capacity World War II DUKW's, nearly 50 per cent of which are now considered unserviceable, the new amphibians will put major emphasis upon marine capabilities and should provide substantially improved water operation, including greater speed and ability to negotiate heavy surf.

Features will include lightweight aluminum construction, 4-wheel drive, interchangeability of engines and power trains for simplicity and maintenance, and large-diameter, low-pressure tires to absorb road shock and improve mobility in sand and off-road terrain.

Antisubmarine Bomber

Lockheed's California Division recently received a $2,000,000 research and development contract from the U. S. Navy "as a first step" toward production of a faster, more protective land-based antisubmarine bomber. The new subhunter—a military version of Lockheed's propjet Electra—will be the Nation's first turbine-powered ASW aircraft. (*Continued on p. 288*)

USI's NEW MILITARY SYSTEMS PLANNING GROUP

U. S. INDUSTRIES, INC., announces the formation of a new Military Systems Planning Group, designed and staffed to help meet tomorrow's military problems . . . today! Composed of leading research engineers with extensive experience in missile support, detection and surveillance systems, this Group represents broad-spectrum capabilities in the field of operations research, applied mechanics, flight dynamics, radar and infra-red technology, guidance and control.

The Planning Group functions as an integral part of USI's central management, coordinating the capacities of the various USI divisions to satisfy and anticipate weapons and space systems needs of the Armed Forces. The 15 divisions of U. S. Industries are active in research, development and production in the fields of automated heavy machinery, electronics, aircraft and missile components, handling equipment for liquids and gases, nucleonics, military ordnance and a wide range of other areas.

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New Army VTOL Craft

Completion of the first transition flight of a tilt-wing vertical take-off and landing research aircraft, Model 76, developed for the Army, has been successfully accomplished. Developed by Vertol Aircraft Corporation of Morton, Pa., under contract with the Office of Naval Research, the Vertol model is the first tilt-wing aircraft to complete successfully the full transition cycle in free flight.

The Model 76 is part of the VTO research program to develop a flying machine combining the high-speed forward flight of the airplane with the vertical flight capabilities of the helicopter. The wing and rotor-propellers are tilted vertically to take off and horizontally for flight like a conventional aircraft.

Air Navigation System

A new navigation system designed to prevent collisions and speed up air safety was demonstrated recently at the Westchester County (N. Y.) Airport by General Precision Equipment Corporation. The new equipment is known as Hidan, for "high-density air navigation" and is entirely contained within the airplane.

The equipment not only can tell the pilot the exact location of his plane but can predict exactly the time of arrival at its destination, it is claimed.

The device would permit much more efficient use of air space because positive separation between planes could be maintained. It also is said to eliminate the need for costly new ground navigation aids, as the equipment is all contained within the plane itself.

Parachutable Tank Destroyer

The M56 Scorpion recently was turned over to troops of the 101st Airborne Division, Fort Campbell, Ky., and the paratroopers lost no time in becoming the first to fire the high-velocity 90-mm. weapon in tactical training. The Scorpion is a low-silhouette track-mounted vehicle capable of negotiating rough terrain at high speed. Weighing less than seven tons, it can be air-dropped from the same kind of assault aircraft which transport paratroopers into battle.

Atomic-Age Lubricants

A series of radiation-resistant fluids for possible use as lubricants, reactor coolants, or hydraulic fluids over a wide temperature range has been developed for the Air Force. Considered a major advance, polyphenyl ethers, composed of benzene and oxygen, remain liquid from 20 to 800 degrees Fahrenheit and retain lubrication characteristics throughout these temperature ranges. Higher temperature exposure is possible for brief periods.

Developed for the Air Research and Development Command, the polyphenyl ethers are two to five times more stable under nuclear radiation than existing organic lubricants. The new fluids were research projects completed by the Monsanto Chemical Company and the Shell Development Company for ARDC's Wright Air Development Center, Dayton, Ohio.

New Powder Container

A new lightweight powder container with a capacity of up to 150 pounds has been developed by the Hercules Powder Company in conjunction with Norquist Products, Inc., Picatinny Arsenal, and Radford Arsenal. Designated the M25 Universal Propellant Container, the new item eliminates inside pockets, corners, and seams and incorporates an inspection port for visual checking in long-term storage and an air-test plug in the lid.

The M25 powder container.

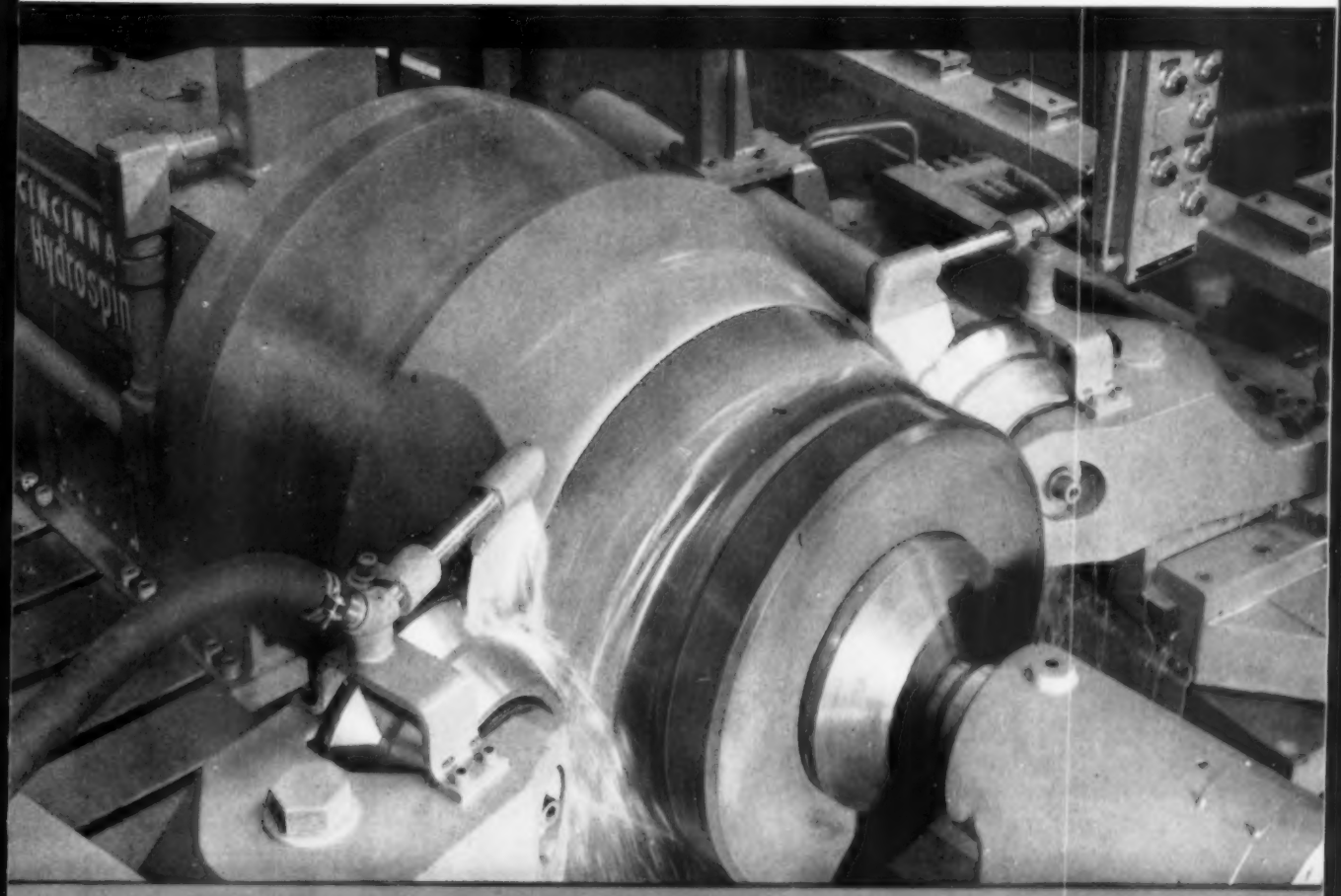
The container has adequate rigidity for normal usage but has sufficiently low bursting strength to reduce the probability of high-order explosions. Sidewalls are of wood veneer double-faced with stainless steel. Bottoms, lids, and hold-down devices are of solid stainless steel.

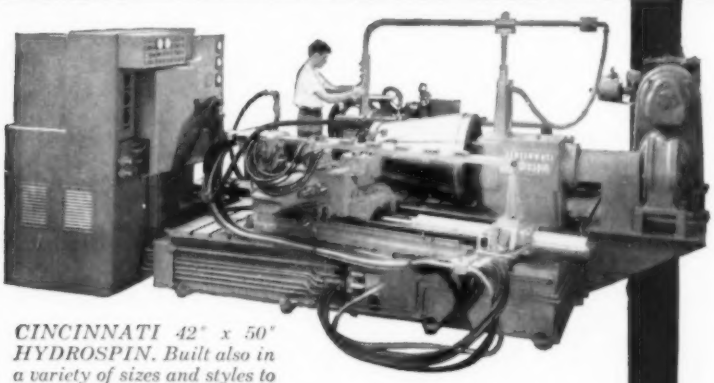
Humidity Via Rocket

Humidity in the upper atmosphere will be determined by a new hygrometer installed in the nose of the IGY Nike-Cajun high-altitude carrier rocket. Secret of its operation is a lead-sulphide cell. Lead sulphide is photosensitive, and the electrical reactivity of the cell is directly proportional to the intensity of the sunlight or radiation beamed on it. Intensity of sunlight, in turn, varies inversely as the amount of water vapor in the atmosphere between the instrument and the sun.

The proportionate change in output of the lead-sulphide cell, which is telemetered back to earth, is thus a measure of the humidity of the rare outer atmosphere in which the rocket does its work. Exposure of the cell to solar radiation is held constant by a sun-follower, an optical system that stabilizes attitude of the instrumentation with respect to the sun regardless of pitch, yaw, or spinning motion of the rocket.

"Missile Age" machining is "Chipless"!





CINCINNATI 42" x 50" HYDROSPIN. Built also in a variety of sizes and styles to meet your missile production requirements.

In developing rocket and missile components, the Cincinnati Hydrospin® can save valuable time and materials in the production of prototype parts. Equally important, the desired part characteristics of high strength, accuracy and fine finish are readily obtainable by Hydrospinning.

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NEW AiResearch steering control system

Combines Acceleration Switching Valves And Hydraulic "Printed Circuit"

More reliable and responsive... this lightweight electro-hydraulic steering control system converts low-level electronic signals from the main guidance system into hydraulic energy which actuates the mechanisms steering the missile.

Packaged as an integrated unit, the three servo valves and six control actuators are mounted on a common manifold and powered by fluid or hot gases. The simplified "printed circuit" system of integral passageways within the manifold eliminates all external plumbing and leakage.

The acceleration switching servo valves provide positive control of spool velocity, thereby achieving greater resolution, reliability and response even at extreme temperatures.

Easily installed and removed as a complete, interchangeable unit, acceptance testing of this compact system can be accomplished prior to missile installation. Suggested applications are: missile surface controls, jetavator controls, and vector and nozzle steering controls. Your inquiries are invited.

Specifications

Actuator load (range)	*90 to 150 in. lbs.*
Electrical input (nominal)	*28 volts DC—10 Milliamperes*
Pressure range	*500 to 3000 psi*
Rated flow	*½ to 2 gpm*
Mounting	*Manifold*
External leakage	*None*
Proof Pressure	*4500 psi*
Burst Pressure	*7500 psi*
Temperature operating range	
Fluid	*-65°F to 450°F*
Ambient	*-65°F to 750°F*
System filtration	*10 microns*

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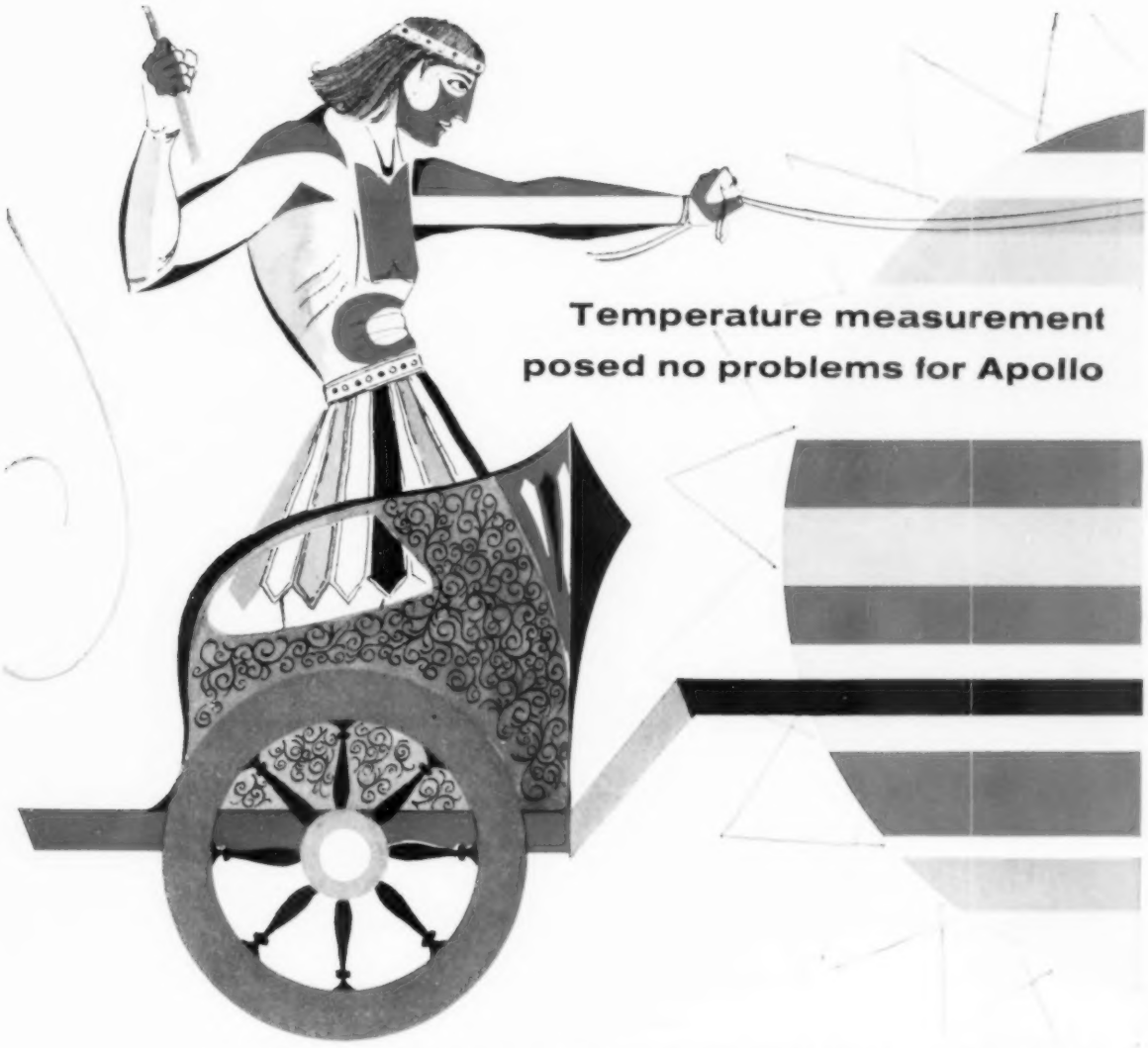

Temperature measurement posed no problems for Apollo

...and you'll have none with the MRC Universal Temperature Measuring System

When Apollo was ranging the heavens he had no temperature problems because he was God of the Sun. Today's missile engineers, being mortal men, have had to find the vital key to many temperature problems in the race to conquer space. Now... after years of development, Magnetic Research Corporation has solved these difficult problems with the Universal Temperature Measuring System. A system so reliable... so accurate... so versatile under all conditions, that it reduces the measurement of temperature to a routine procedure.

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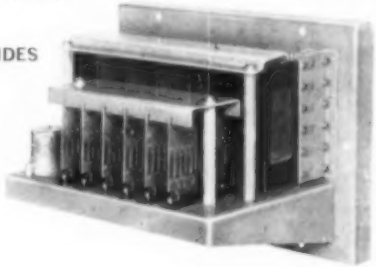

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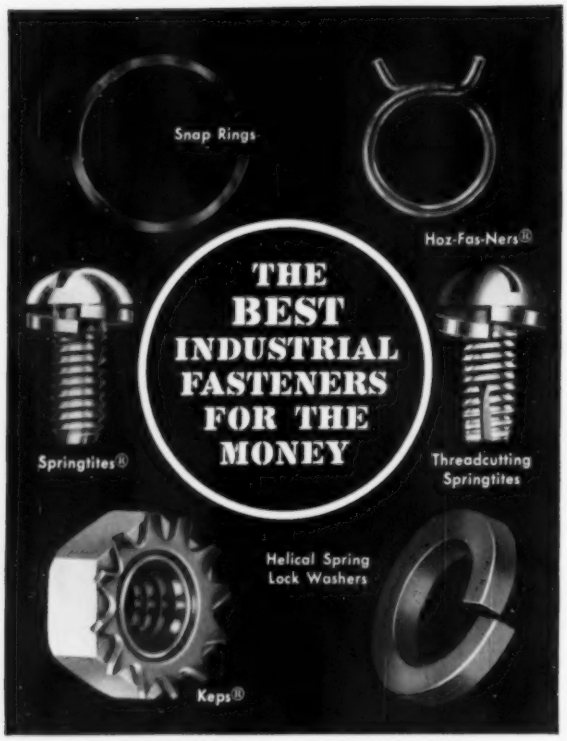

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MATERIALS PROGRESS

George S. Brady

Synthetic vs. Natural Rubber.—A recent study made by McGraw-Hill indicates that nearly a million and a quarter tons of chemicals, not including carbon black, are used annually in compounding rubbers. These chemicals include emulsifiers, plasticizers, extenders, antioxidants, accelerators, stabilizers, pigments, and modifiers.

To the industrial buyers and users of rubbers, this fact demonstrates that there are not merely the six or eight kinds of rubber which are listed when production figures are given, but that the number of possible variations of rubbers with different characteristics is almost infinite. Rubber research laboratories not only are varying the chemistry and compounding to fit new industrial end-use needs, but they are searching continuously for entirely new types of rubbers.

During World War II, synthetic rubber was an emergency product to meet a deficiency of natural rubber, and the doubt of its useful replacement value was such that at the end of the war steps were taken to compel use of a certain proportion of synthetic in order to keep the man-made rubber plants active for another emergency. This situation now has been so reversed that we could satisfy all military needs for rubber even if importation from the Far East were entirely cut off.

At the start of the Korean war the price of natural rubber jumped to more than double the price of synthetic, but today the precarious competitive position of natural rubber would hardly support any serious price differential. Synthetic now holds a two-to-one use position over natural rubber, even though the new plants for the production of the newer types of "synthetic natural rubber" are not yet in commercial operation.

In fact, it is freely admitted that the subject of what to do with the large stocks of natural rubber may need an "agonizing appraisal." Published figures indicate that we have about 1,250,000 tons of natural rubber in the stockpile, costing around $20 millions annually merely for maintenance.

Technical men in the industry prefer to use the term "elastomers" for synthetic rubbers. Most of these materials come under the very broad classification of plastics, and are not chemically rubber. Only the newer polyisoprenes, with the same chemical building block as natural rubber, can be classified technically as true synthetic rubber.

Recent reports from the Army Quartermaster Research and Development Command indicate that the polyisoprenes such as *Firestone*'s Coral rubber have proved in tests to be practically identical with natural rubber in physical qualities and in aging. Other tests have indicated some superior qualities and greater uniformity. The isoprene used in these rubbers is synthesized from plentiful domestic raw materials, so that rubber is no longer a strategic material.

Elastic Synthetic.—While a definite degree of resilience is required for most industrial uses of rubber, the full elasticity of natural rubber normally is not needed for industrial rubber products. But *Goodyear-Gulf Chemicals, Inc.*, Cleveland, Ohio, now has in the experimental stage a new synthetic rubber that it believes is more elastic than natural rubber. Called Deuterio

Colonel Brady is a consulting engineer, author, and editor, Washington, D. C. He is a well-known authority in the field of materials, and his "Materials Handbook" is a recognized source of information on the subject.

Vought Vocabulary

Cru·sad′er III: *Navy's new automated fighter is a flying missile base*

Automation multiplies the efficiency of the pilot of Chance Vought's new all-weather fighter.

Its armament battery of guided missiles puts him in command of a missile base that flies at more than twice the speed of sound. Its advanced equipment provides him electronic vision, instant reactions. Freed by automation from cockpit routine, he focuses on strategy. Multiplied in power and judgment, the Navy pilot of this *Crusader III* becomes a *multiple man.*

One of the most versatile weapon systems ever devised for America's defense, this new interceptor can fight at altitudes above 95 percent of the earth's atmosphere. It will operate – under all weather conditions – from carrier decks or advanced airbases.

Crusader III will give the U. S. Navy the *lowest cost,* all-weather Mach 2-plus fighter available.

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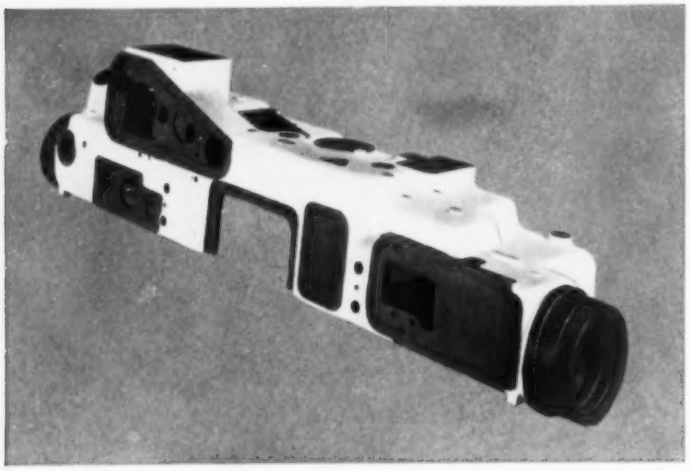
rubber, it is of the polyisoprene type but has deuterium (heavy hydrogen) attached to the carbon chains instead of ordinary hydrogen atoms. Deuterium atoms have less attraction for each other than have hydrogen atoms, which makes the product more fluid-elastic.

Vulcanization without Sulphur.—*Hercules Powder Company*, Wilmington, Del., has developed a method of rubber vulcanization without the use of sulphur by making a carbon-to-carbon cross-linking of the molecules with a peroxide vulcanizer. It gives greater heat resistance for tire use and also a lighter-colored rubber.

The use of silica instead of carbon black also has made possible bright colors in rubber, but more important is the increased wear resistance. Up to 45,000 miles of wear life have been shown for the silica-filled tires. *Godfrey L. Cabot, Inc.*, has now gone into the manufacture of this "white carbon black" which previously was imported from Germany. This company's Cab-O-Sil is 99 to 99.7 per cent pure silicon dioxide, with a particle size of 15 to 20 millimicrons, made from silicon tetrachloride.



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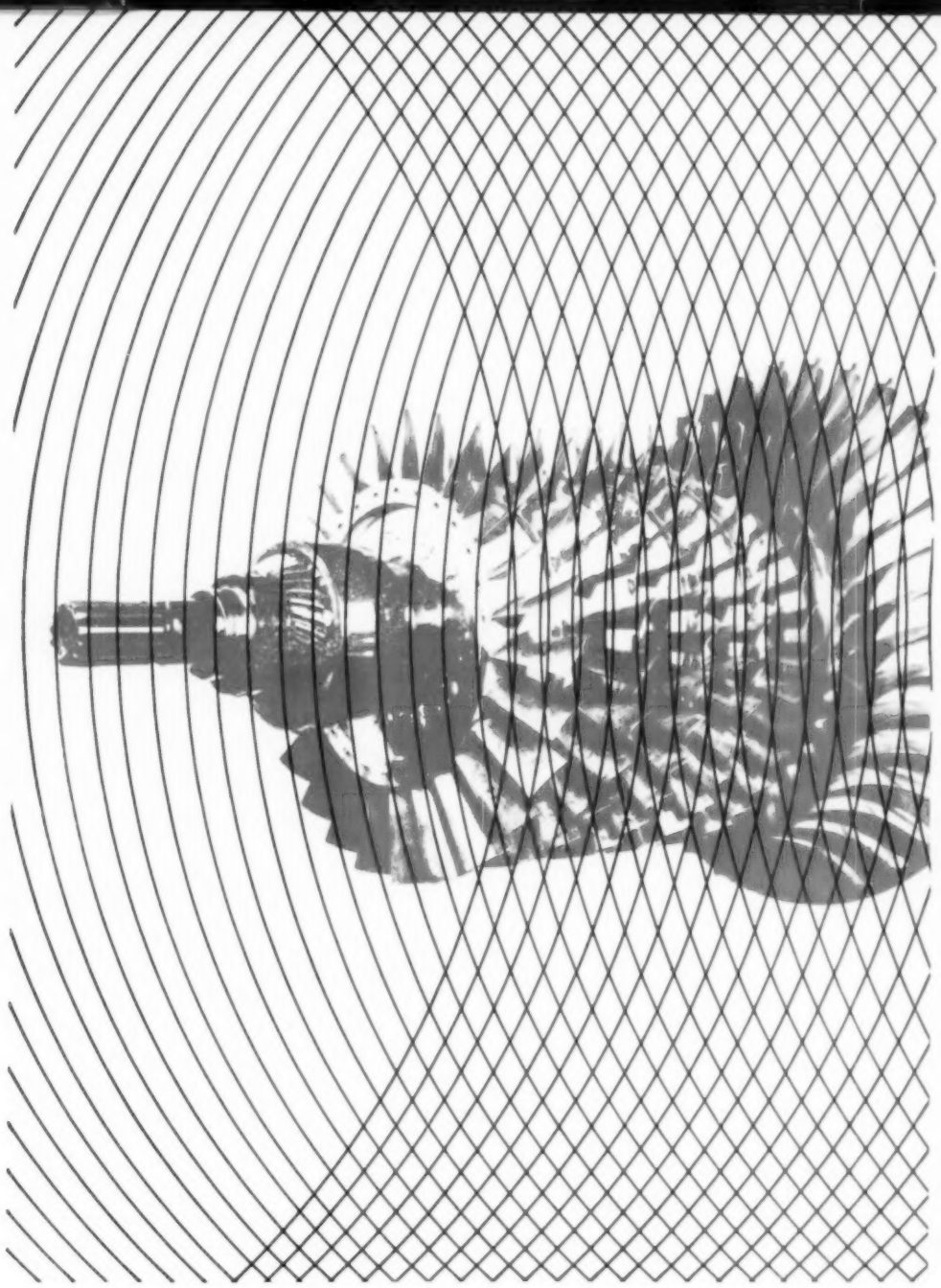
Eyes for Satellite.—The "weather eyes" on the Army satellites for collecting meteorological data have a practical simplicity of materials design. The entire optical unit weighs only 3.5 ounces. The two eyes are mounted back to back to look in opposite directions through 3-inch holes in the satellite, with a direction of view at a 45-degree angle with the rotation axis and covering about 600 miles at a sweep. The satellite rotation is about one revolution a second.

The eye cell is of 0.010-inch Type 430 stainless steel welded to the cylinder. The parabolic quartz mirror is bonded in place with Pliobond cement. The infrared energy from the clouds is focused on a tiny square lead-sulphide detector, and the signal is recorded on magnetic tape from whence it can be released on command from ground telemetering stations. The ribs holding the detector are of Type 430 stainless steel spot-welded to the main cell and silver-soldered to the detector cell. The steel parts are gold-plated to minimize the effects of radiant energy. Silicon solar batteries, to differentiate between day and night, are mounted in the frame holding the detector.

Thin Oxide Film.—Aluminum-oxide film no more than a millionth of an inch in thickness, or about one-twentieth the wavelength of light, has been produced by the *Westinghouse Research Laboratories* for use as supports in electronic imaging tubes. The thin, transparent film permits electrons to pass through without interference, but it is exceptionally strong as a support. The film is made by rubbing off the oxide film on one side of a sheet of aluminum foil with a strong alkali, and then placing the foil in an acid solution to eat away the aluminum metal, leaving the thin oxide film from the other side.

Nylon Machine Screws.—For electrical and electronic uses, *Gries Reproducer Corporation*, New Rochelle, N. Y., is producing a line of nylon machine screws with round, fillister, and flat heads, automatically molded to close tolerances in sizes from 4-40 to ¼-20. The stock color is the natural off-white of nylon, but any color may be had. Where the strength of metal is needed and insulation is required, the company has developed an automatic insert-molding technique to anchor nylon or other plastic heads to metal screws. The plastic heads may be had in colors for matching with finishes or for coding.

Superhard alloys.—Fine, hard silicate crystals separated by an aluminum matrix give exceptionally good wear characteristics to the superhard aluminum-silicon alloys, making the alloys very suit-



Lycoming's T53: 860 horses ride the earth, sea, and sky. Compact and rugged, the T53 gas turbine engine packs a roaring 860 horsepower. Its versatility is amazing: not only does the T53 power aircraft, but it is adaptable to industrial and marine use as well. It is a product of Avco's Lycoming engineers who are shaping a new age of power for America.

AVCO

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able for engine cylinder blocks. But casting and machining of these alloys has hitherto presented a difficult problem. Now, newly developed foundry techniques and improved machining methods have made it possible to specify these alloys for engine use. *Aluminum Company of America* is recommending a new alloy for this purpose. Called Hi-Si alloy, it contains 20 per cent silicon and when heat-treated has a hardness up to 740 Brinell. It also has a very low heat-expansion factor. *General Motors* has in the experimental stage a V-8 aluminum engine weighing 30 per cent less than standard engines.

Investment Casting.—Another new development in aluminum is the application of investment casting to the production of aluminum parts of intricate design, with considerable increases in physical properties as compared with conventional aluminum castings. Aircraft parts as thus made by the *Arwood Precision Casting Corporation* have a minimum tensile strength of 34,000 pounds per square inch with elongation of 3 per cent.

New Type Roofing Sheet.—In a new type of aluminum roofing and siding, *Kaiser Aluminum & Chemical Sales, Inc.*, has departed from the conventional round corrugations long standard for iron roofing and has a crimped-channel design which prevents siphoning of water between overlapping sheets. The aluminum channeled sheets have an embossed diamond pattern to diffuse glare and also to strengthen the sheet so that lighter gauges can be used.

Silicon Bronze.—*Chase Brass & Copper Company*, Waterbury, Conn., has a new grade of silicon bronze in which there is no free silicon segregation to cause hard spots. The alloy, called Silnic, contains some nickel, and is age-hardenable. The bars come in either hard or soft tempers. The hard-temper material can be machined, and it needs no further heat treatment. The alloy retains high strength at elevated temperatures.

Oilless Bearings.—New Fluoroglas oilless bearings of *Fluorulon Laboratories, Inc.*, Caldwell, N. J., are composed of a fluorocarbon resin with glass particles and an inert pigment filler. The material requires no lubrication, has good wear and chemical resistance, and will withstand continuous temperatures to 500 degrees Fahrenheit. The coefficient of friction is 0.04, compressive strength 600 pounds per square inch, and Durometer hardness D50 to D65.

Plastic for Cans.—Scientists in the *Department of Agriculture*'s Northern Research Laboratory, Peoria, Ill, are convinced from experiments that hard plastic films can replace tin coatings on most food cans. Among the coatings tested were vinyl ethers made from soybean and linseed oils. The coatings adhere well to black iron sheet, are flexible and resistant to abrasion, and are not injurious to the foods in the can.

Plastic Pipe.—Plastic pipe that is claimed to be as strong as metal pipe with only one-eighth the weight of steel pipe is being produced by the *Amercoat Corporation*, South Gate, Calif. It is made with an epoxy resin reënforced with interwoven glass-fiber filaments and heat-cured. It is rigid, does not cold flow or sag, and will withstand a working pressure of 500 pounds per square inch. The pipe comes in 20-foot lengths with plain, flanged, or bell-and-spigot ends in sizes from 2 to 12 inches. It is highly resistant to most chemicals, and as it is nontoxic it can be used in food-processing plants.

Seamless Tubes.—Glass-reënforced epoxy resin also is used for a new line of seamless tubes being produced in rounds, squares, and rectangles by the *Chemfab Corporation*, Long Island City, N. Y., under the name of Chemtube. The tubes are

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Here's cost-cutting news if you must package defense items.

Official load limits for triple-wall corrugated have been increased

Look at these new load limits!

by truck

350 lb.

gross weight

An interim revision of PPP-B-640 governing shipments to the military procurement services now increases the load limits for triple-wall corrugated containers from 250 lb. to 350 lb. This revision PPP-B-00640a, became effective January 14, 1958.

by rail

275 lb.

gross weight

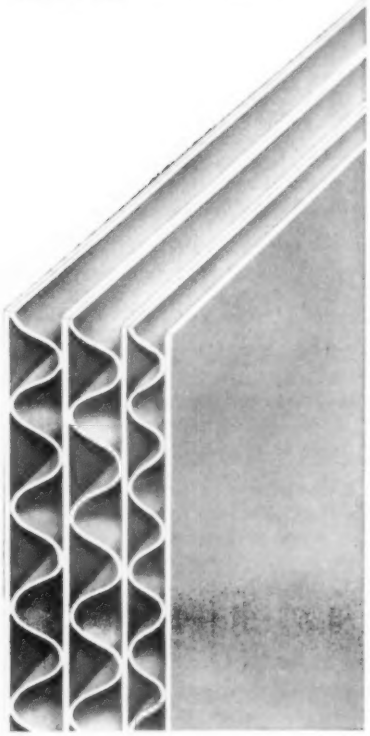
(If Rule 41 applies)

350 lb.

gross weight

(If Rule 41 does not apply)

A supplement to Rule 41 of Uniform Freight Classification 4 now permits use of triple-wall corrugated board to package rail shipments up to 275 lb. with a size limit of 120 united inches. Prior to the change in Rule 41, shipments in corrugated were limited to 160 lb. For those products that do not come under Rule 41, gross weights up to 350 lb. are now allowed.



A switch to triple-wall corrugated can cut your packaging costs

The cost of packaging often can be the difference between successful and unsuccessful government bids. For packaging is an inevitable part of the cost of producing and delivering practically every product that the government buys. Packaging specifications are strict, and for some products the packaging cost can be a significant part of the total bid.

With triple-wall corrugated now approved for higher loads, you can immediately switch the packaging of many products from wirebounds or wooden boxes to low-cost Tri-Wall Pak containers.

Tri-Wall Pak is a sturdy triple-wall corrugated board that has meant amazing savings for many users in recent years. It fills the gap between ordinary corrugated and wood as a packaging medium. It is a clean, easy-to-handle packaging material that combines high strength with low tare. Containers are made to your dimensions and are delivered flat for easy storing.

Our packaging engineers are ready to show you how containers made of Tri-Wall Pak can mean packaging economies and lower bids for your company. Write for assistance and literature.

Tri-Wall Containers, Inc.

799 Washington Street, New York 14, N. Y. · Telephone: CHelsea 2-8500

The triple-wall construction of Tri-Wall Pak was developed by Tri-Wall Containers, Inc. Manufacture is protected by U. S. Patent 2,759,523. Other patents are pending.

Tri-Wall Pak is the registered trademark of Tri-Wall Containers, Inc.

Materials Progress (Contd.)

rated for a service temperature of 400 degrees Fahrenheit. The tensile strength is 22,000 pounds per square inch, with a flexural strength of 32,000 pounds per square inch, and a dielectric strength of 500 volts per mil.

Linear Acetal Sheet.—The new *Du Pont* plastic Delrin was inadvertently described in the May-June issue as a polyvinyl acetal. This plastic is produced from formaldehyde and it does not have the $(-CH_2:CH-)$ basic linkage characteristic of the vinyl compounds. The polymerization of formaldehyde in this reaction produces a $(-CH_2-O-CH_2-)$ basic linkage, and the plastic has been designated by the company as a linear acetal. A physical difference is that the plactic sheet is hard and rigid, while a polyvinyl acetal sheet is soft and flexible.

Plastic Bellows.—A new expansion bellows for piping systems that can replace bellows made from expensive alloys for corrosive service is being made by the *Resistoflex Corporation*, Roseland, N. J., from molded high-density Teflon. It can be used for working temperatures of 450 degrees Fahrenheit, and will withstand working pressures of 120 pounds per square inch, permitting a bending deflection to 70 degrees and an axial movement to 2 inches, with long flex life.

New Ball Valve.—A ball-type valve that has no metal parts is being produced for chemical plant use by the *B. F. Goodrich Industrial Products Company*, Marietta, Ohio. It is made of Koroseal with self-lubricating Teflon seats for the ball. It is available with threader or socket ends in sizes from ½ to 1½ inches for 140-pound pressure at 100 degrees Fahrenheit, and in 2- and 3-inch sizes for 100-pound pressure.

Aircraft Electrical Wire.—Another application of Teflon plastic is as an insulation coating for aircraft electrical wire being produced by the *Western Insulated Wire Company*, Los Angeles, Calif. The wire, called Bronco 500, is of silver-plated copper in sizes 10 through 20. The Teflon insulation exceeds the specification requirements for Type EE (1,000-volt) aircraft wire. It has a dielectric constant of 2.15, has no measurable moisture absorption, is highly resistant to oils and solvents, and has an operating temperature range from minus 90 to plus 250 degrees centigrade.

Heavy-Duty Pumps Seal.—For handling a situation where metal pump seal rings in contact with an abrasive slurry and 98 per cent sulphuric acid failed after a relatively few hours of operation, *Crane Packing Company*, Morton Grove, Ill., produced a seal ring of Haynes metal-ceramic LT-1. This material is composed of 77 per cent chromium metal powder and 23 per cent alumina. The molded material has a Rockwell hardness up to 42, has high thermal shock resistance, and is highly oxidation resistant.

New Insulating Sheet.—*Continental Diamond Fibre Company* has a new insulating sheet that combines the good electrical characteristics of vulcanized fiber with the moisture resistance of plastic laminates and retains the lower cost of the vulcanized fiber. Marketed as Vulcoid, it is made by immersing wet indurated vulcanized fiber in a water solution of alkaline formaldehyde. The sheets can be punched, machined, sawed, or formed into shapes.

Extruded Titanium Parts.—Wright Aeronautical Division, *Curtiss-Wright Corporation*, working in conjunction with the Air Matériel Command, has been extruding titanium parts directly from cast ingots. Both alloyed and unalloyed titanium have been employed. Savings in cost up to 40 per cent as compared with the cost of forged parts have been indicated, and the parts have superior mechanical properties.

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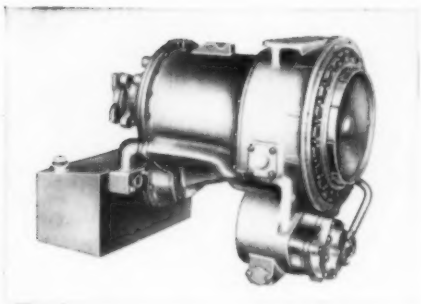

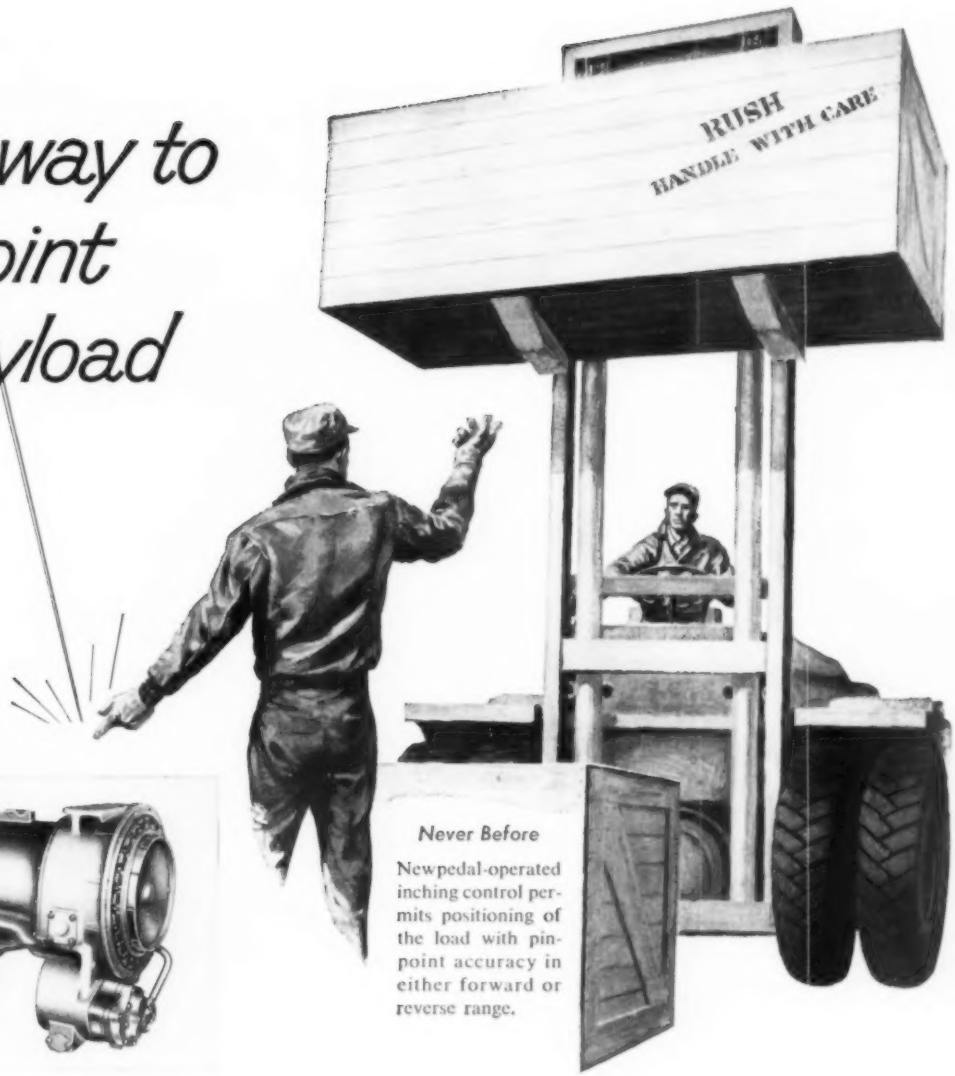

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Allison TORQMATIC **TORQMATIC DRIVES**

ROCKETS AND GUIDED MISSILES

Alfred J. Zaehringer

Astronautics.—A sophisticated earth satellite is now in the works. The Air Force WS-117L Pied Piper reconnaissance satellite is to be launched from Cooke Air Force Base, Calif., probably around January 1959. The Thor IRBM will be used as a first-stage booster. Additional stages will be added to orbit satellite packages of 1,200 to 1,500 pounds.

Lockheed Aircraft Corporation is working on the system which will first carry instrumentation and then optical cameras. Aim is to get a picture of the earth from altitudes of 300 to 400 miles. Exposed film is to be ejected from the satellite and recovered by means of a parachute or some other device. At the present time, there is no plan to equip the satellite with a TV camera (*viz.*, "Big Brother") or to place man into an orbit.

Initially some five or six satellites are planned covering a 2-year period. Cost is estimated at about $260 million. A 5-year program, covering twenty satellites, also is being planned. Launchings are to be in a north-south direction. Eventually the Atlas ICBM will be used as a booster.

Exploration of space around the moon will be studied by both the Air Force and the Army. Firings will be attempted before the end of the year. The Air Force is under Air Research and Development Command's Ballistic Missile Division, and three moon shots are assigned by the Advanced Research Projects Agency.

The Army program is under the cognizance of the Ballistic Missile Agency at Redstone Arsenal. The Army will be assigned two shots. Total Air Force-Army program cost through fiscal year 1959 will be $80.2 million. The Air Force will use the Thor IRBM as a first stage, the second-stage Vanguard rocket, plus a third stage consisting of the Vanguard solid rocket or NACA fluorine-hydrazine rocket.

The Army's moon vehicle will use the Jupiter IRBM as first stage, a cluster of eleven modified Sergeants as second stage, three solid Sergeants as third stage, and a single Sergeant rocket as fourth stage. Aim of the project will be to circle the moon rather than impact it. After circling the moon—and relaying moon conditions back to earth via radio—the vehicle will have enough velocity to return to the earth.

Aërodynamics.—Additional information regarding the reëntry problem of ballistic missile nose cones has become available. The nose cone enters the atmosphere at speeds of three to five miles a second. The air in front of the cone is compressed and heated. A strong shock wave is formed and two types of drag result—a wave drag in front of the cone and skin drag as the viscous air travels over the missile nose.

The reëntry time is brief—under a minute—but the shock-wave temperature goes up to 15,000 degrees Fahrenheit, the air layer next to the skin goes to 12,000 degrees Fahrenheit, and the cone surface is at about 5,000 degrees Fahrenheit. Rate of heating is over 2 BTU/sq. in./sec.

This heating is about as severe as that occurring in the hot blast of rocket combustion chambers where heat-transfer rates up to 5 BTU/sq. in./sec. have been measured. It should be noted that the heat transfer in a modern steam generator is about 0.03 BTU/sq. in./sec. and peak values for internal-combustion engines are about 0.07 BTU/sq. in./sec.

As the nose cone enters denser atmosphere, the pressure may go up to 1,000 p.s.i. in a few seconds. A jet plane, for example, may encounter a skin temperature of 650 degrees Fahrenheit at a pressure of 1 p.s.i.

Several approaches are being evidenced in production nose cones. Army's Jupiter nose cone will be long and slender with a rounded tip. The cone itself may be made of reënforced plastic which presumably will burn away in layers—thus heat will be removed. The Air Force Atlas, Titan, and Thor will have very blunt noses and will be constructed of "heat-sink" materials such as copper or beryllium. These materials will absorb heat rather than remove it as in the case of Jupiter.

The Navy is believed to be taking another approach with Polaris—the use of a ceramic absorbing material. It is felt that heat removal, or ablation as it is called, offers the greatest problem to aërodynamic heating. However, within the next five years, as conditions become even more severe, fluid cooling or the use of magneto-hydrodynamics may come into play.

Missiles.—With the many U. S. missiles well along in development or actually in production, increasing attention is being paid to the future line of missiles. One of the most impressive of these new weapons is the TCBM—the transcontinental ballistic missile. The TCBM, being fostered by the Air Force, will have a range of 11,000 miles and will be able to reach almost any target on earth from the U. S.

It is likely that such a TCBM will use an Atlas or Titan as first stage with the payload section being equipped with aërodynamic surfaces or wings. In effect, the missile would become a hypersonic glide bomber.

Meanwhile, the Air Force has let two development contracts for the Dyna-Soar orbital reconnaissance bomber. About $5 million has been allocated for development of this boost-glide manned rocket bomber. Final vehicle cost is estimated at $150 million each.

First construction contract—for $10 million—is being awarded for 6 Atlas launching pads at Warren Air Force Base, Wyo. The base, near Cheyenne, will have a total cost of $65-100 million.

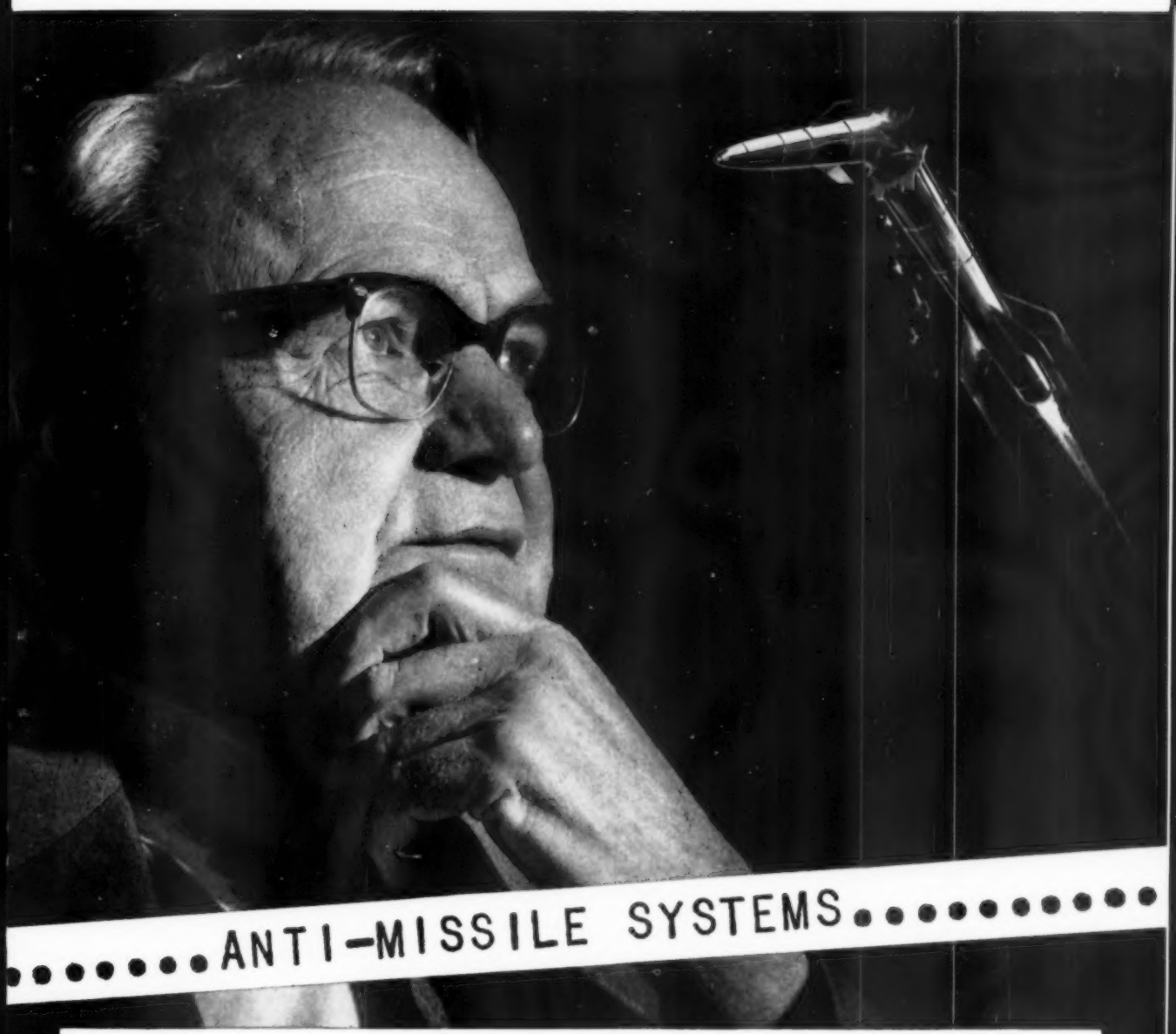
New Navy missiles include: Arcon, Iris, Eagle, Betty, Hot Point, Katie, Boar, Raven, and Hopi. Arcon and Iris are meteorological sounding rockets. Eagle is an air-to-air missile. Betty carries a nuclear depth charge. Hot Point carries an atomic warhead. Katie missile can be fired from a 16-inch naval gun. Boar, Raven, and Hopi are air-launched rockets.

Antimissiles have again been in the news. The Nike-Zeus missile will be designed as a multipurpose weapon. Without booster, it can be used against aircraft; with booster, it will be designed for antimissile use.

Though the Army has the responsibility for developing the Nation's antimissile system, the Department of Defense has reactivated the Air Force Wizard project and $3 million has been allocated for research and development for fiscal 1958. A new Wizard allocation is to be made for fiscal 1959.

In addition to the Army's Nike-Zeus, a mobile "anti" system called Plato is being pushed forward. Plato work is proceeding on a $4.5 million contract.

Mr. Zaehringer, president of the American Rocket Company, Wyandotte, Mich., is a recognized authority on astronautics, guided missiles, and jet propulsion.



A Research Project of Dr. Harry Nyquist,
Senior Scientist, Stavid Engineering, Inc.

Dr. Nyquist is a pioneer in advanced areas of electronics such as Information Theory and circuit noise, and is credited with nearly 150 patents in the field of communications. He is now contributing his exceptional analytical ability to Stavid's work on a far reaching anti-missile system. Men like Dr. Nyquist are typical of Stavid's outstanding scientists and engineers who are working on advanced concepts . . . years ahead of actual systems development.

In Stavid's objective engineering atmosphere, scientific, development and manufacturing teams are producing a wide range of electronic systems for all branches of the military. Typical of such projects is the REGULUS missile command guidance system, designed, built and maintained in operational status by Stavid.

CURRENT STAVID PROJECTS INCLUDE:

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ARMAMENT ELECTRONICS

W. H. Van Vliet

Bomarc Guidance.—Westinghouse Electric Corporation recently has been awarded a contract to develop and test a ground-control system to guide the Bomarc missile. The system to be developed is for a more advanced guidance from launching to the built-in terminal guidance which will take over and direct the missile on a collision course with the target. Longer-range control, automatic tracking, and personnel reductions are among some of the improvements envisaged.

Antijam Filters.—The Atlas missile radio-inertial guidance system is virtually proof against jamming, since the use of coded antijam filters reject interference. Highly selective filters using time, frequency, and space coding make enemy jamming very difficult because each Atlas antijamming device is unique to the missile. In addition, radio guidance is only provided during the first few moments of the missile flight, and then it is over friendly territory.

Hyfinder.—The Air Research and Development Command recently has announced a crash-locator beacon which automatically ejects itself from an aircraft before a crash and floats down in the vicinity on a parachute. The device, which operates on land or sea, flashes a stroboscopic light which is visible for about 25 miles. In addition, it transmits homing signals and SOS on HF and VHF. The entire system weighs fifty-six pounds and includes a rubber raft for water operation and an extensible tripod for ground use.

Star Tracking.—Nortronics Division of Northrop Aircraft has announced a long-focal-length star tracker using electronic scanning. The unit has such a narrow field of view that it is possible that a star may be located, locked-on, and tracked during daylight. Nortronics states that a star fairly close to the sun may be used in spite of high ambient light. The star-tracking system will be usable for space navigation as well as for stellar guidance systems for missiles.

Micromodules.—The Army's micromodule concept recently was announced jointly by the Signal Corps and RCA. A micromodule consists of a stack of ceramic wafers upon each of which one or more components have been fabricated. The micromodule wafer is 0.3-inch square and is intended for use with semiconductor devices. The interconnected micromodule is not intended for repair, and replacement only will be effected as maintenance. It is expected that reliability will gain. These individual components connected into a stage or stack will reduce equipment size and weight greatly. The Air Force and Navy have indicated interest in the program, and it is expected that they will share in a joint military research and development effort.

Infrared.—New developments in infrared detectors and techniques may add greatly to detection of aircraft and missiles. A recent development, which may prove to be far more sensitive to infrared than present lead-sulphide detectors, has a response of less than one microsecond. Additionally, the Air Force may apply infrared to its airborne early-warning systems. An airborne infrared detection system used above 20,000 feet would negate the atmospheric conditions which plague ground infrared detection systems.

Electronic Brains.—The installation of a new $1,500,000 electronic brain at Lockheed Missile Systems Division's Palo Alto computing center is emphasizing the increasing tempo of activity on Lockheed's two high-priority space-age projects—the Navy's underwater-launched Polaris missile and the Air Force's huge reconnaissance satellite. Capacity of the division's computing facility—one of the most up to date in industry—was more than doubled when the new Univac scientific digital computer was installed. The Remington Rand computer with its associated equipment occupies 1,900 square feet of floor space. A twin of the present 1103A at the Lockheed laboratory, the new unit will be modified this fall to make it the most advanced of its type in the Nation. Additional components will be installed to give it an even greater capacity for quickly solving the complex problems of satellite and missile technology.

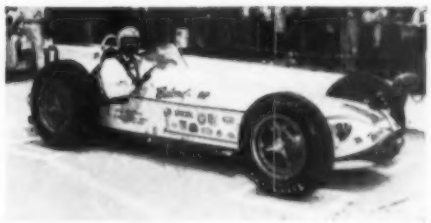
Precision Crystal Filters.—Hughes Aircraft Company recently made available to industry a series of precision crystal filters. These filters are of a unique advanced design permitting center frequencies of 30 kc. to 30 mc. and fractional bandwidths of 0.01 to 6 per cent. The new filters embody the advantages of high-frequency filtering, high selectivity, low passband ripple, low insertion loss, small size, as well as temperature, shock, and vibration stability.

Tartar Missile Radar Sets.—The Navy Bureau of Ordnance recently announced that the Sperry Gyroscope Company has been awarded a $27.5 million contract for production of Tartar missile radar sets and associated equipment. The contract, with Sperry's Surface Armament Division, is in addition to recently disclosed Navy contract awards totaling more than $75 million for production of Talos and Terrier guided-missile radar systems.

Traveling-Wave Tube Amplifiers.—A new line of traveling-wave tube amplifiers has been announced by Hughes Aircraft Company. Typical of the new products is Hughes MAS-1A tube. It is an S-band periodically focused traveling-wave tube amplifier with power outputs of one kilowatt over a frequency band of 2,000 to 4,000 megacycles. Peak power outputs are obtained with duty cycles up to 0.005 when operated with one-watt drive. The tube has a gain of 30 to 33 db., giving an excess of one kilowatt over most of the band. The type of permanent-magnet focusing field employed in the MAS-1A eliminates the solenoid, solenoid power supplies, and solenoid heat dissipation. The MAS-1A incorporates the permanent magnets required for periodic focusing in an all-metal package, thus minimizing external magnetic fields.

Space Navigation.—Wright Air Development Center has requested proposals from a number of companies for three types of systems for space navigation. Essentially, the systems will be for interplanetary travel, for extraterrestrial landings, and for controlling the orbit and altitude of a recoverable satellite.

Lieutenant Colonel Van Vliet, U.S.A.F. (Ret.), formerly director of armament electronics, Northeast Air Command, and formerly chief of the Operations Division, Air Force Ammunition Services, is an electronics systems engineer in the California Division, Lockheed Aircraft Corporation, Burbank, Calif.



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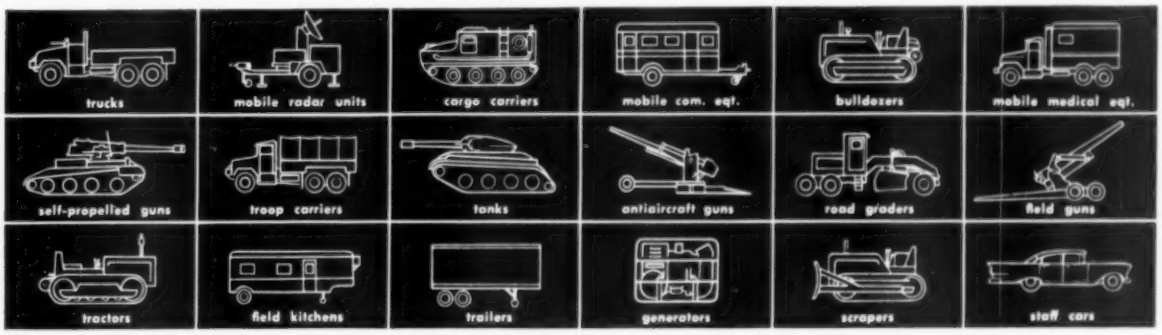

AIRLIFT EQUIPMENT is an excellent application for lightweight magnesium wheels. Many types of vehicles used for airlift and air-drop operations, as well as for electronic housings and other types of military equipment, are made with magnesium. Shown above is airlift equipment ideally suited for magnesium alloy wheels. For more information, contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1412F.

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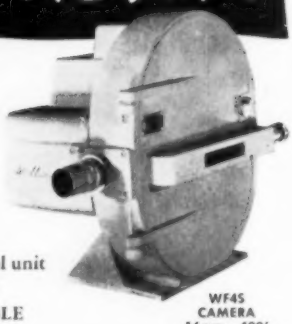

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SPACE ARMAMENT

New Army-Navy Sounding Rocket

An outstanding example of Army and Navy coöperation was demonstrated at White Sands Missile Range, N. Mex., recently with the first firing of a revolutionary new rocket that measures wind velocity and temperatures sixty miles above the earth. Called the Aerobee-Hawk, the rocket was fired by the White Sands Signal Agency in recent initial tests. One of the unusual aspects of the new rocket is the variety of component parts, which are:

A motor from the Army's Hawk, a missile designed for use against low-flying aircraft; tail fins from a Navy-Army Signal Corps Aerobee; nose cone from a Navy-Army Signal Corps Cajun.

In addition, the new rocket is being fired from an Army Nike launcher at the Navy blockhouse at White Sands.

Data collected from the firings are being given to scientists of the International Geophysical Year program and are being studied for possible tactical employment of the rocket as an aid to intercontinental ballistic missile firings.

Aerobee-Hawk crews, working with ICBM experts, could furnish important facts about the vital 60-mile-high region. This information could be fed to ICBM computers to give the giant missile's steering brain advance data.

It is also expected to aid in future nuclear tests, measuring wind direction and speed to avoid fallout of harmful materials.

Second Nose Cone Recovered

The Army successfully launched a Jupiter intermediate range ballistic missile on July 17th and recovered its full-size nose cone intact. The missile traveled the desired distance and impacted accurately in the predetermined target area. It was the second time an IRBM full-scale nose cone had been recovered after safely returning from a trip through outer space. The first feat was accomplished by the Army's Jupiter on May 18th. Both missiles were launched from the Air Force-operated Atlantic Missile Range at Cape Canaveral, Fla. The cone was located and recovered at sea by the U. S. Navy.

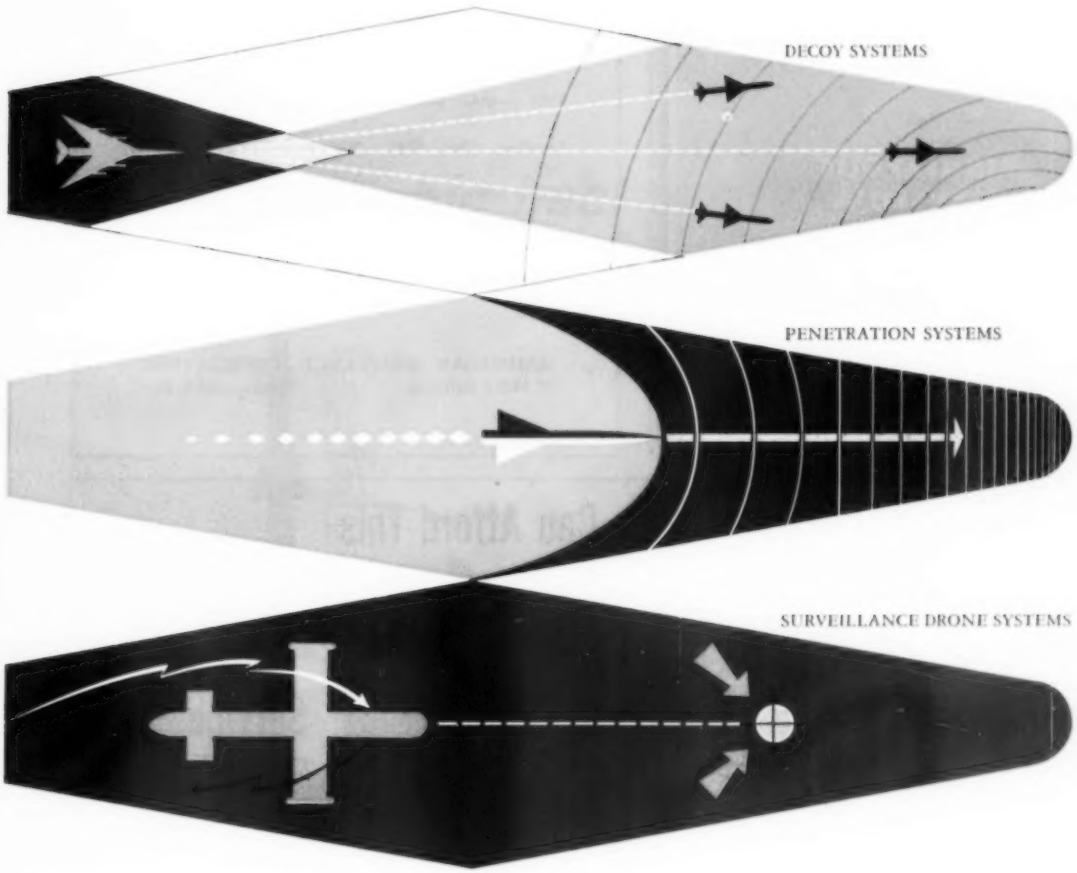
These three recoveries affirm that Army missilemen have found a satisfactory solution to the warhead-protection problem. The Jupiter cone affords necessary protection against aërodynamic heating as the object reënters the atmosphere at a speed of about 10,000 miles an hour. Without this protection the terrific heat would melt the cone and cause the warhead to be destroyed short of the target.

The nose cone was designed and developed by the Army Ballistic Missile Agency, Redstone Arsenal, Ala., and one of its contractors, the Cincinnati Testing and Research Laboratories, Cincinnati, Ohio. ABMA developed Jupiter and is responsible for the space-exploration projects undertaken by the Army. ABMA is one of the major elements of the Army Ordnance Missile Command.

The cone recovery gear, developed by the Cook Electric Company of Evanston, Ill., was intricate and included a large colored balloon, dye marker, signal lights, and radio transmitter to aid in the location, and a capsule of shark repellant to protect the "frogmen" who entered the water to secure the cone.

DRONE and SMALL MISSILE SYSTEMS

Research and Development at Rheem Aircraft Division has a record of achievement in the field of drone and small missile systems. The capability for complete "program management" is manifested in the list of current and completed projects and the areas of responsibility covered.



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INDEX TO ORDNANCE

VOLUME XLII

● The Index to Volume XLII of ORDNANCE, with title page for binding, is now available. It will be sent free of charge upon request to the Editorial Offices at the address below.

● It covers subjects in the following 1957 and 1958 issues: July-August (No. 223); September-October (No. 224); November-December (No. 225); January-February (No. 226); March-April (No. 227); and May-June (No. 228). It is arranged alphabetically by subject and author.

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- ☐ Military and management consultation and operations analysis
- ☐ Automatic structures design programming
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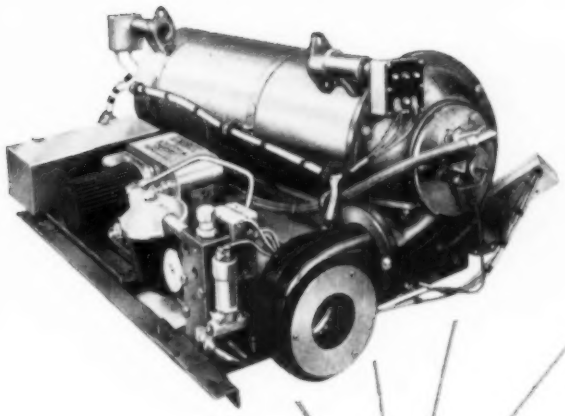

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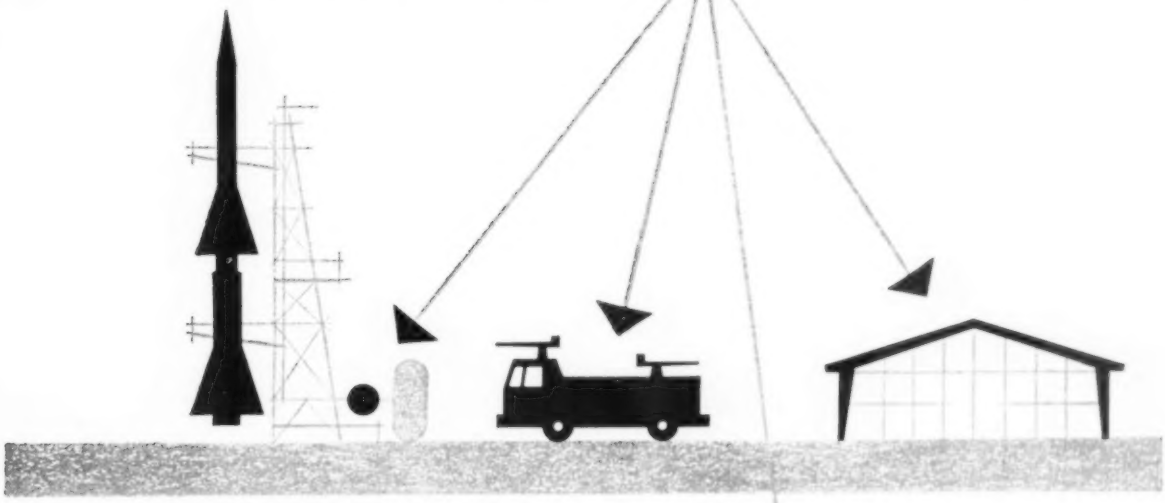

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RECENT PATENTS

This department on recent military-industrial patents is being published in ORDNANCE *to keep our readers informed of the latest developments in these fields. The data are compiled by Melvin Nord, patent attorney, Detroit, Mich. Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each.*

Removable-Cell Battery.—*U. S. Patent No. 2,832,815. Issued April 29, 1958, to Casey Bremer and Edward Rosenthal:* This invention provides an electric storage battery construction especially arranged to facilitate the removal, repair, or replacement of individual cells of the battery. When servicing is required, each individual cell component, as well as the case, if necessary, can be replaced readily without damaging the other components. Military applications of this invention could be in combat and transport vehicles, aircraft, missiles, submarines, and communications.

Device for Loading Bombs.—*U. S. Patent No. 2,822,931. Issued February 11, 1958, to Wilber S. Sparrow:* This invention provides a device for loading bombs, rockets, torpedoes, guided missiles, or other projectiles. The object of the invention is to provide means for automatically retaining the bomb support at a constant angle of inclination to the horizontal while it is being raised and lowered. As the bomb support does not tilt as the bomb is being raised, the bomb does not have to be securely lashed to it. It is sufficient that the bomb rest in position on the support under its own weight.

Smoke Tracer Composition.—*U. S. Patent No. 2,823,105. Issued February 11, 1958, to Thomas Stevenson and Winston W. Cavell. Assigned to the Secretary of the Army:* This invention provides smoke tracer compositions which are susceptible of direct ignition by the propellant and produce a smoke trail, originating at the gun muzzle and extending over at least 1,000 yards of trajectory, without emission of light, or with emission of a controlled intensity. An example of such a composition is the following: strontium peroxide, 70 per cent by weight; calcium resinate, 15 per cent; 1-methylaminoanthraquinone, 15 per cent.

Target Seeker.—*U. S. Patent No. 2,823,612. Issued February 18, 1958, to Arthur Cox and Catherine Ledda. Assigned to the Secretary of the Air Force:* This invention describes a target-seeking head for supersonic guided missiles, with an optical system included in it for transmitting light rays of a target to a focus on a focal plane for the control mechanism of a missile.

Air and Oxygen Supply.—*U. S. Patent No. 2,824,557. Issued February 25, 1958, to Jacques G. Mejean and John V. Oliveau. Assigned to Aerotec Corporation:* This invention relates to apparatus

Fig. 1. High-altitude suit.

for supplying oxygen to the helmet and air to the suit of aircraft personnel when at a high altitude (Fig. 1). Provision is made for supplying oxygen from the aircraft or from an emergency supply carried by the suit when the aircraft supply fails or when the suit is disconnected from the aircraft in bailing out. The invention maintains the air and oxygen at predetermined pressures relative to the ambient atmospheric pressure and relative to each other.

Air-Dropped Grenade.—*U. S. Patent No. 2,826,990. Issued March 18, 1958, to William P. Gross. Assigned to the Secretary of the Army:* This invention provides a grenade which can be dropped from aircraft into the path of advancing troops or infiltrators. The grenade contains time-delay mechanisms which, at a predetermined interval after the grenade has contacted the ground surface, eject grapnels and connect trip wires. The inner end of each trip wire is secured to arming means for detonating the main explosive charge. The purpose of the time-delay device is to delay the ejection of the grapnels in the event that the grenade strikes an object, such as the limb of a tree, before it finally reaches the ground.

Mine-Mooring Device.—*U. S. Patent No. 2,824,516. Issued February 25, 1958, to David K. Studenick. Assigned to the Secretary of the Navy:* This invention describes a means for mooring a mine at a predetermined depth when a sufficient number of magnetic signals have been received from the mooring cable of the mine by a magnetic measuring device to lock the cable to the mine anchor. Neither a bight in the cable nor a plummet line is required.

Toxic Incendiary.—*U. S. Patent No. 2,824,515. Issued February 25, 1958, to James C. Loftin, Leo Finkelstein, and Edward M. Wharton. Assigned to the Secretary of Defense:* This patent describes toxic incendiary bombs, adapted to be dropped from aircraft, which give off fumes of cadmium oxide upon burning. These fumes are exceedingly toxic. The bomb is a hexagonally shaped body. It consists of a cast magnesium-cadmium alloy and is filled with a Thermit-type charge.

Upon impact of the nose the inertia of the firing pin causes the point to strike the primer cap which flashes into the depression of the first fire charge so as to ignite the latter. The gaseous products of combustion blow out vent-hole plugs, thus preventing the explosion of the bomb. The first fire charge burns at a temperature sufficiently high to ignite the Thermit charge which in turn ignites the magnesium-cadmium casting. An intense incendiary action is obtained; and upon burning of the casting, a cadmium-oxide smoke or aerosol is formed which is extremely toxic. Thus, in order for the bomb to be safely extinguished the firefighter must wear a gas mask having a filter which will give protection against the cadmium-oxide aerosol.

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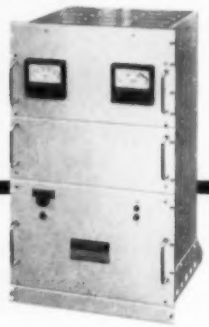

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BOOK REVIEWS

Reviews in this issue by:

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COL. GEORGE S. BRADY, *consulting engineer, author, editor, Washington, D. C.*

COL. LEO A. CODD, *editor, Washington, D. C.*

DR. JAMES B. EDSON, *consultant on electronics, Research and Development Division, U. S. Army, Washington, D. C.*

F. W. FOSTER GLEASON, *military historian, ordnance analyst, editor, Washington, D. C.*

LIEUT. COL. S. M. SMOLENSKY, *engineer, Andover, Mass.*

The Great Arms Race. By Hanson W. Baldwin. New York: Frederick A. Praeger, Inc. 116 pp. $2.95.

THIS review is being written as United States Marines are landing in the Middle East. While the book under discussion was prepared some months ago, it is, in the reviewer's opinion, a most informative and authentic source of information to guide thinking people as to the full implications of our latest military venture. The text presents comparisons of current United States and Soviet military power.

The name of the author of this volume is a byword among military students and analysts the world over. Hanson Baldwin has the well-merited distinction of superb authorship, factual analysis, and sound conclusions unsurpassed among military writers anywhere.

Several chapters of this book appeared originally as articles during February and March 1958 in *The New York Times* and *The New York Times Sunday Magazine*. The data disclosed are up to the minute.

The author describes where we stand in all major defense categories in strategy, missiles, missile-firing submarines, piloted aircraft, nuclear weapons, air defense, navies, armies, and men. The Russians are ahead of us in some areas—we are ahead of them in others. The problem facing the United States is one of balance as well as of speed-up.

Mr. Baldwin concludes his study with some very timely and trenchant proposals as to improvement in meeting our defense obligations. One of these has needed saying a long while and only recently has obtained the emphasis it deserves.

This is the area of relationship between Government and industry in the development and procurement of modern weapons. Government procurement policies are coming under increasing criticism in that they insist upon the closest possible sort of direction, supervision, and centralization. In the author's words:

"Incentive has been reduced and individual initiative has been circumscribed. So much red tape and so many controls have been established that our lead time for the production of new weapons systems has sometimes been longer than the Soviet lead time. In the opinion of many of our experts, the Government's

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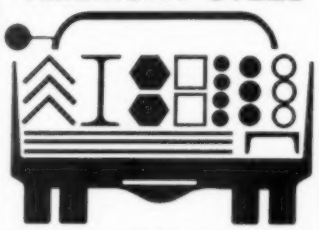

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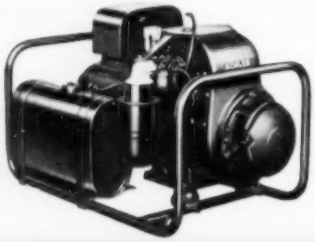

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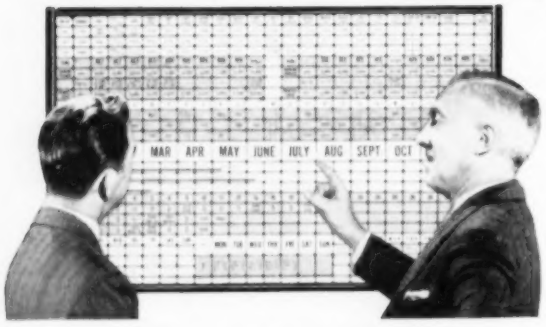

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Book Reviews (Contd.)

procurement policies tend to kill the goose that laid the golden eggs."

The author also brings out in this connection certain fallacies on which some segments of industry itself are proceeding. "Less red tape," writes Mr. Baldwin, "and more initiative for industry in development and procurement and production contracts are essential. But, at the same time, private industry should halt some of the direct and indirect attacks that have been made periodically against Government (particularly the Army and Navy) research laboratories, proving grounds, and such test stations as Redstone Arsenal. There is more than enough work for both Government and private research and development agencies; the two can, and must, complement each other if the United States is to achieve optimum progress in weapon development."

Through the years Hanson Baldwin has written many important studies of our defense progress. In the light of current international events, especially our involvement at the very doorstep of the Soviet Union, none has been more timely and revealing than this portrayal of the current relative strength of the military power of the United States of America and the Union of Soviet Socialist Republics.—L. A. Cobb.

The Phantom Major—The Story of David Stirling and His Desert Command. By Virginia Cowles. New York: Harper & Brothers. 320 pp. $3.95.

GENERAL Montgomery is reported to have said to his staff officers: "The boy Stirling is mad. Quite, quite mad. However, in war there is often a place for mad people." Major Stirling was not mad, but he had a brazen daring. He had no use for ordinary Commando operations. For him they were too formal, too planned. He believed that it was necessary to improvise on the spot.

Against the continued opposition of staff officers who did not like "private wars," Stirling fitted out small groups of daring men who were able to penetrate far behind the German lines in North Africa and destroy large numbers of aircraft on the ground. His favorite operating tool was the American jeep, fitted with four British Vickers K guns, with which he could circle the roadless desert and reach the airfields behind the lines.

With usually no more than three men, he could gain entrance to the airfields and plant combination explosive and fire bombs of his own invention in the parked aircraft. Once he was able to take advantaage of a poorly guarded field and bring in his jeeps to destroy all the planes by gunfire. So great was his destruction of airplanes that Rommel had to direct personally the final determined effort to capture the man whom the Germans called "The Phantom."

Military readers may be surprised to find that in this book a woman writer has done an exceptionally outstanding job of recording and interpreting the operations of these super Commandos. The book makes interesting and instructive reading.—George S. Brady.

Behind the Sputniks—A Survey of Soviet Space Science. By F. J. Krieger. Washington: Public Affairs Press. 380 pp. $6.

A review of the hearings before the Preparedness Investigating Subcommittee of the Committee on Armed Services, United States Senate, during late 1957 and early 1958 clearly establishes the urgency for early decisions to implement a long-range space program for the United States. Since then, it appears that little has been done to "get on with the job." "Behind the Sputniks" by F. J. Krieger should be a sober reminder to all responsible officials that time is fast running out.

This is the first exhaustive study historically tracing the development of astronautics in Russia from the turn of the

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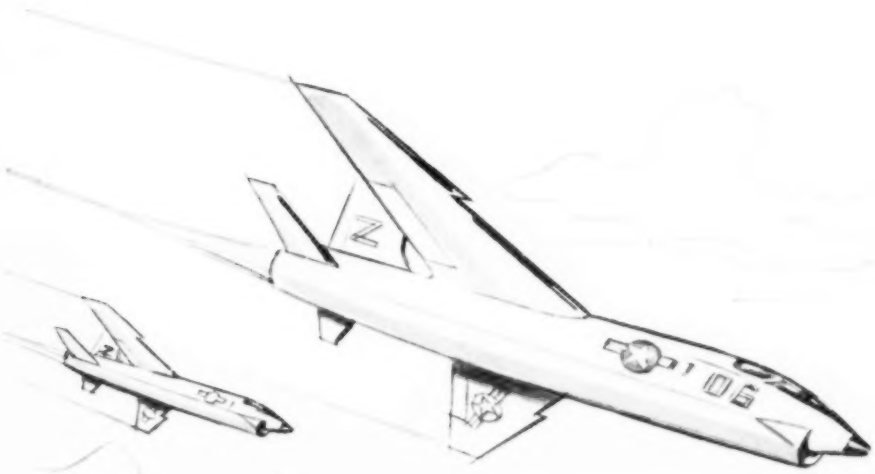

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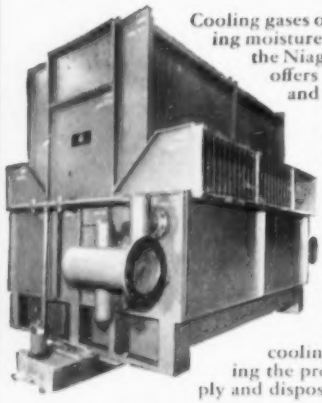

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Book Reviews (Contd.)

century to the launching of Sputnik I. The material has been prepared for the most part from original Russian papers as part of a long-range research project for the U. S. Air Force.

This timely volume presents in a fascinating and authoritative way recent Soviet research and ideas on such matters as artificial satellites, flight to the moon, interplanetary communications, biological aspects of space travel, atomic airplanes, trips to planets, and worldwide television broadcasting from space.

The survey clearly shows how the Communists, in their drive for world domination, are applying their typical bulldozer tactics to the conquest of outer space. Their program shows a singleness of purpose and is as serious as interest in science can be when sponsored by a totalitarian regime. Obviously they have made the decision to "get on with the job."—S. M. SMOLENSKY

Electronic Measuring Instruments. Second Edition, Revised. By E. H. W. Banner. New York: The Macmillan Company. 496 pp. $7.95.

THIS is the second edition of a general and comprehensive survey of electronic test equipment covering the theoretical principles, the various types of practical application, advantages and limitations, and typical equipment in general use.

The book is a reference tool for test equipment engineers, for electronic personnel desiring to know more of the scope of electrical measurements, and for the student with some knowledge of electronics.

Use is made throughout of British standard terminology, symbols, and spelling of technical terms. The American reader will not find this format a handicap but probably will be unfamiliar with the commercial types of equipment given as typical examples. The readable style should more than compensate for any inconvenience experienced by use of terminology, etc., and the citing of British equipment does not detract from the principles and concepts of the measurement techniques involved.—J. W. BARNES.

Nuclear Reactor Experiments. Edited by J. Barton Hoag. New York: D. Van Nostrand Co. 480 pp. $6.75.

YOU are there! It is your hand that fills the micropipette, your eye that matches the tracer solution to the index mark. The tiny droplets gleam as you press them out on the sample plate. You check and load the counting chambers; the counters roll. Then come the charts and the neat rows of numbers as your mind marshals the data and computes the answers.

Next, you are piling carbon blocks (the very identical blocks that once were in Fermi's first pile) and arranging uranium rods to make an "exponential"—a piece of a pile that you will use to calculate the size of the completed article. Soon, with a mingled confidence and caution that flows from your growing skill, you are adding more uranium, counting and charting the results as you sneak up toward "critical mass."

Finally, after these and many other adventures, you "ride" the control panel of a working reactor, using it to measure its own characteristics and for various other experiments. Power and period meters and control rods and the scram button become real. You think hard and carefully about what to do in case of this or that emergency.

This book is a laboratory manual prepared by the staff of the Argonne National Laboratory for their course in reactor technology. So vividly real is the description of the experimental techniques that, for someone who has had any kind of laboratory experience, the reading will evoke a rich connotation, a sense of actually being there.

The book requires in the reader a reasonable fluency in the basic nuclear concepts and in elementary algebra and calculus. For such it offers a rewarding technical and literary experience.—JAMES B. EDSON. *(Continued on p. 316)*

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Book Reviews (Contd.)

The Guns at Gettysburg. By Fairfax Downey. New York: David McKay Company. 290 pp. $5.

THOUGH still writing more from the viewpoint of an artilleryman than of an ordnanceman (the difference is subtle but real), Colonel Downey treats of matériel with much more fullness than in his "The Sound of Guns." There is also greater avoidance of technical error. The listing of guns of various types and their technical characteristics is far superior. Of particular interest is the meticulous placement of the guns at the present Battlefield Park, with notes on some errors and substitutions.

The author's main thesis—that Gettysburg was decided by the guns and that the splendid work of Gen. Henry J. Hunt (to whom the book is dedicated) was the greatest factor in the success of the Union artillery—is virtualy undebatable. Other tactical comment is sound: Pendleton erred gravely in permitting twenty-five rifles and sixteen Napoleons to remain unused (though near by) in the main bombardment, in moving the ammunition train, in establishing the straight gun line which denied the advantage of converging fire. Ewell, too, was as deficient in his use of guns as in his failure to grasp fleeting opportunities.

Large-scale maps, one for each day, a fourth for an over-all view, are adequate. So are the 155 notes, some of which correct the errors of previous works. Seven appendices and a large bibliography are included. Ordnancemen will note that the index lists, separately twelve types of gun under "cannon"—an improvement over ninety-five per cent of the works dealing with military history.—F. W. FOSTER GLEASON.

Research and Development Procurement Law. Edited by Albert C. Lazure and Andrew P. Murphy, Jr. Washington: The Federal Bar Journal. 496 pp. $5.

THIS very readable book of 496 pages contains a wealth of authentic information previously published in *The Federal Bar Journal* and here assembled in one volume for ready reference. It includes professional analyses by members of both the legal and engineering fraternities. In its pages are discussed the new conditions in the Federal Government, especially as they relate to the legal complexities of contractual and procedural problems, with emphasis on the legal aspects of research and development.

The studies included in this book were largely under the direction of a special committee of the Federal Bar Association under the chairmanship of Col. Albert C. Lazure, U.S.A.R., Chief Counsel, Ordnance Corps of the Army.

It is difficult to see how any individual, company, or group presently engaged in research or production for the defense services can well proceed without the type of information presented in this volume. Here are reviewed the techniques which are connected with modern armament, many of which were unknown even a decade ago.—L. A. COBB.

The Background of Napoleonic Warfare. By Robert S. Quimby. New York: Columbia University Press. 385 pp. $6.75.

THIS is a study of the field tactics during the Napoleonic Wars, and, in order to understand the bases for these tactics, the author has considered as background the operations of the two preceding centuries. He has quoted freely from early military experts—Saxe, Maizeroy, Boucet, Guibert, Pirch, Du Teil, and others—whom the author believes were the "makers of systems" during this period when the musket and artillery were incorporated as necessary equipment of an army and when cavalry changed its nature from a flamboyant display of personal armored knights to an over-all useful tool for reconnaissance and decisive thrust.

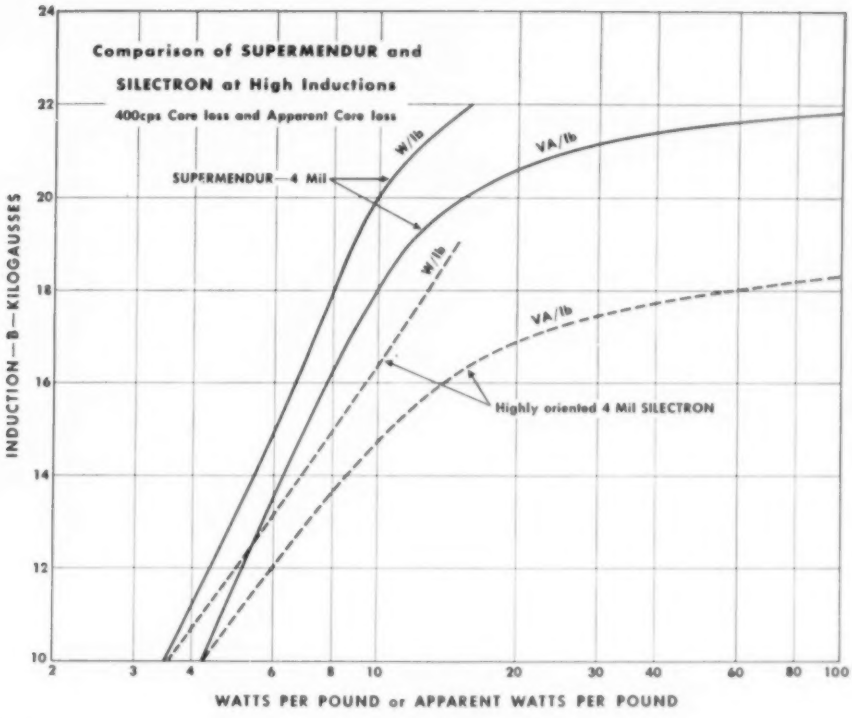
In the past century the airplane, telephone, radio, and radar have altered the communications position of the field commander, and it is now perhaps possible to guide field operations from a map at a headquarters far removed from the field. But basic principles have not changed, and there are plentiful indications that distant control has vital weaknesses.

Napoleon was adept at utilizing equipment tactically for effective fire. In the early stages, before the exhaustion of French manpower by the campaigns in Russia and Spain, Napoleon's troops were rigidly trained to an astounding effectiveness in firepower, while the British phalanx method of fire required 450 rounds for each hit. What amounts to phalanx firing is still much in vogue with the Western nations, and the linking of field tactics with firepower is a subject still needing study. The reader will find this book profitable reading as a basic military text.—GEORGE S. BRADY.

Sputniks Into Space. By M. Vassiliev with V. V. Dobronravov. New York: Dial Press. 181 pp. $3.75.

IN spite of some favorable press reviews, this reviewer is not impressed by this book as a scientific work. It was obviously intended as propaganda within the U.S.S.R., and in America it would fit into science fiction rather than into serious scientific literature.

The best that might be said of the book is that it may possibly meet the publisher's hope that it will give the reader an insight into Soviet scientific thinking. From this standpoint it may be worth a serious perusal.—GEORGE S. BRADY.



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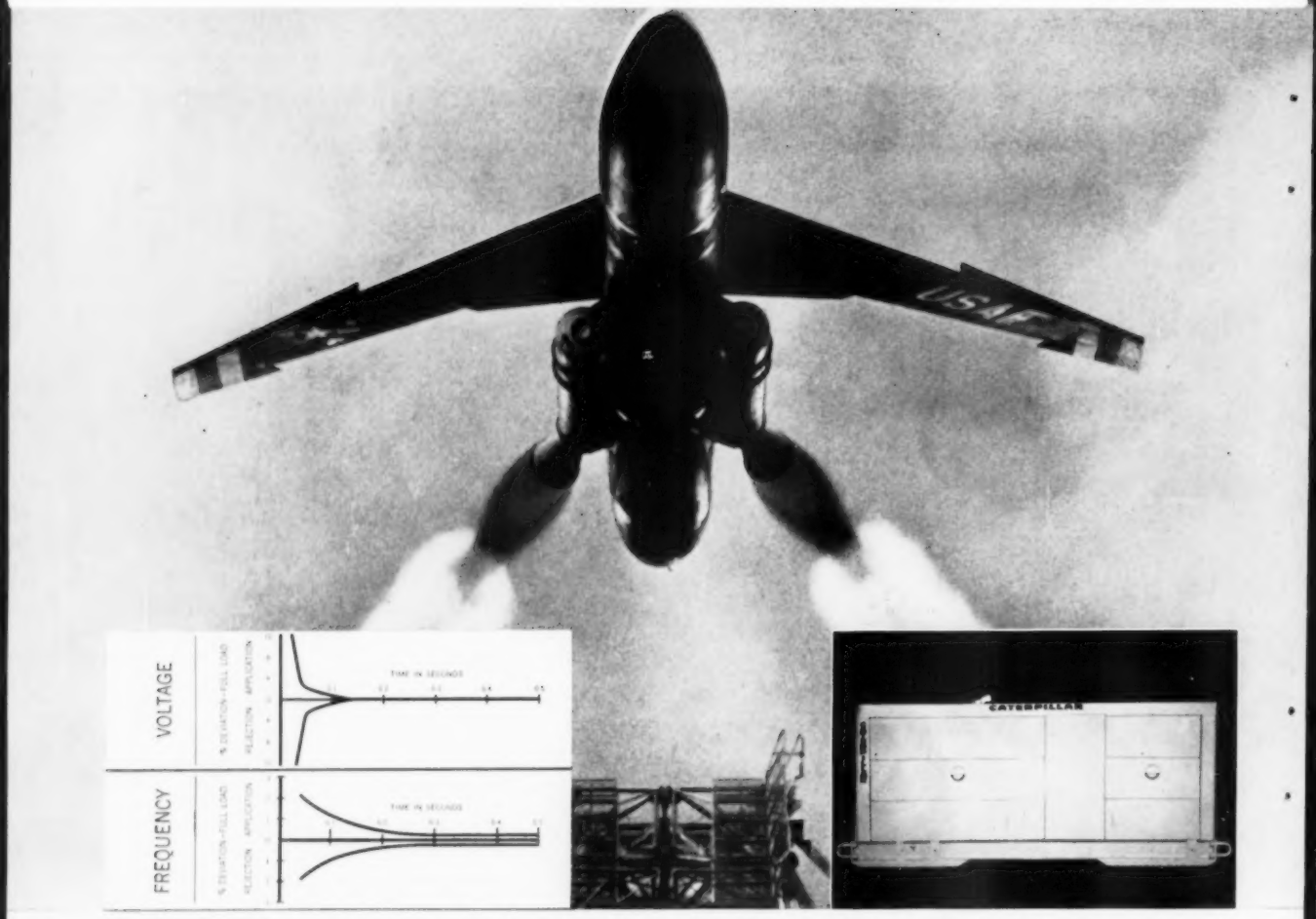

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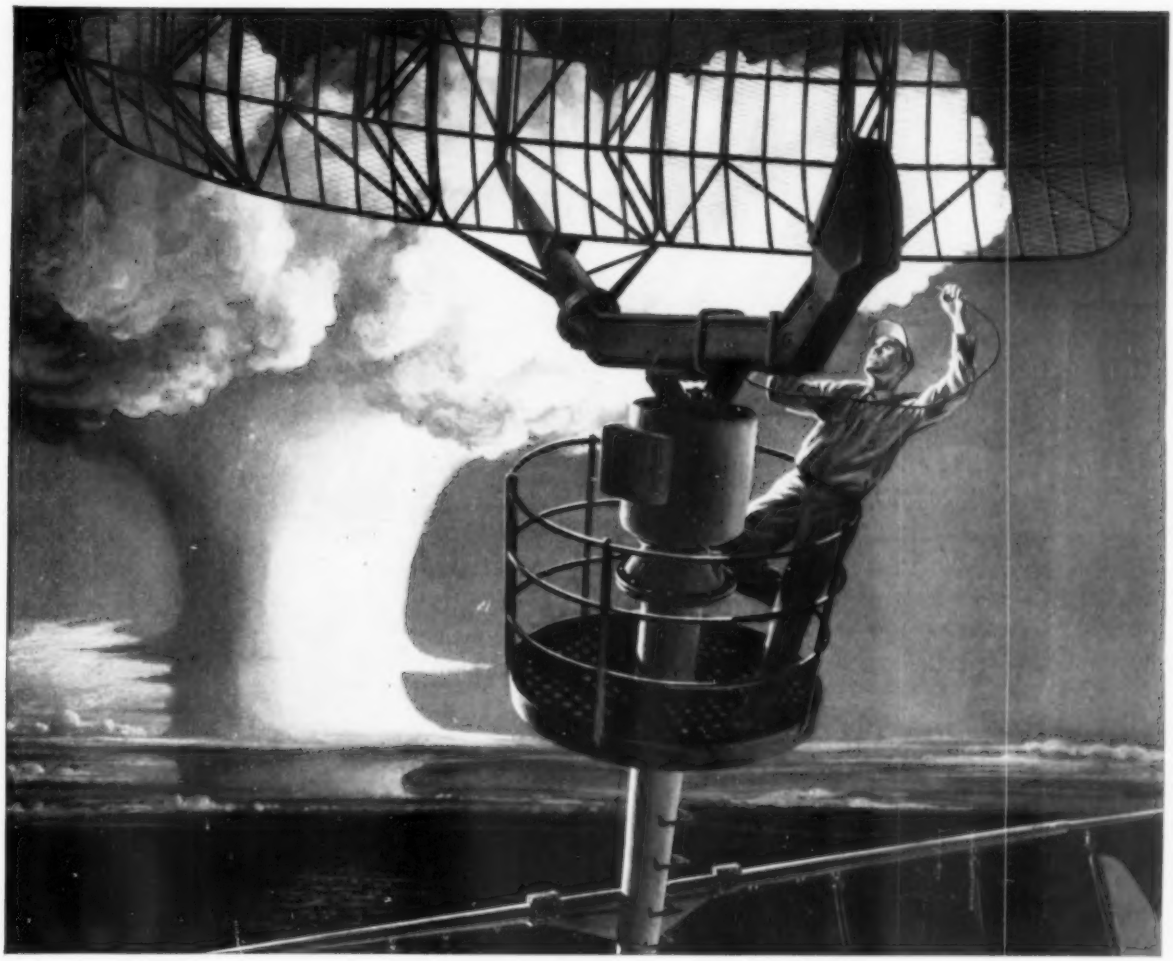

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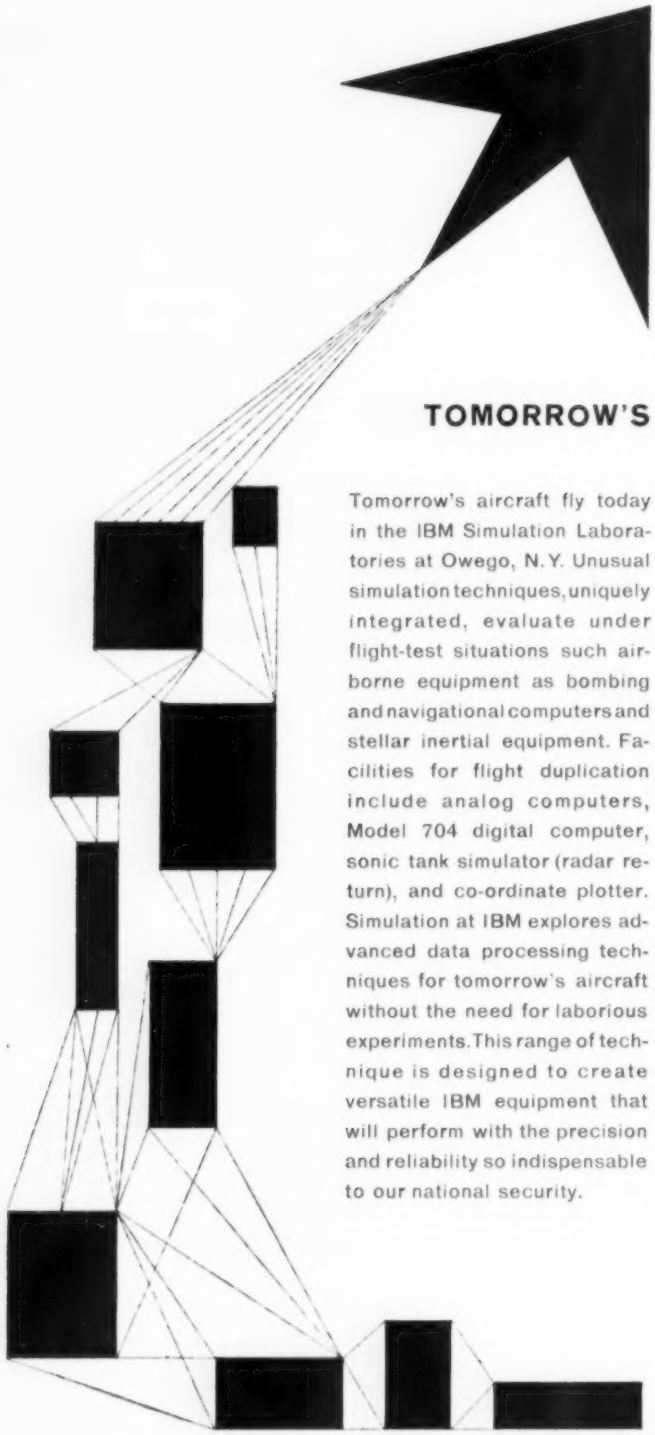

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Power from the Sun

Solar energy has wide possibilities for industrial and military use

Joseph Goodyear

Aëronautical journalist and industrial writer, Ridgewood, N. J.

THE radio of the first Vanguard satellite, successfully placed in orbit last March, obtained its power from solar batteries which tapped the virtually unlimited energy of the sun, converting it into electricity.

Many who read this announcement became aware for the first time that attempts were actually being made to harness a portion of that tremendous amount of energy that reaches the earth each day from its source 93 million miles away.

ACTUALLY, the solar batteries of Vanguard I are a culmination of research that has been under way since perhaps the dawn of technology. In recent decades, and especially in the past few years, the attempt to utilize solar energy has gained tremendous impetus in many countries of the world. A coördinating agency of this work—the Association for Applied Solar Energy—at a recent world meeting in Arizona, was host to scientists and other representatives from thirty-seven countries, including the Soviet Union.

Today solar energy is being used, not only as the power source for the Vanguard batteries, but in high-temperature furnaces and boilers; in home heating and cooling units; in clocks, GI helmet radios and Air Force research balloons; in telephones, portable radios, and cigarette lighters; in beacons, cookers, and water pumps; and in sewage disposal, sea-water distillation, and food production.

Most of these projects are, of course, only on an experimental basis, and at this stage—with a few important exceptions—solar energy appears to be a less efficient and more expensive method of accomplishing something that is currently done by other power sources. The potential of solar energy, however, like that of nuclear energy, is impressive, and its application to ordnance and logistics offers an interesting and perhaps promising avenue of research. It might be well, therefore, to consider some of the basic factors involved.

SOLAR energy is an attractive power source because of its abundance. Some 1,000,000,000,000,000 (that's one thousand trillion) kilowatts of solar energy are wasted daily. The amount that strikes the United States alone is enough to supply the world's current power requirements 10,000 times over.

It is obvious that if even a small percentage of this tremendous energy could be put to use economically, many of the world's power requirements and power shortage problems could be solved. Unlike atomic energy, solar energy requires no critical mass such as uranium, presents no health hazard other than sunburn, and has no waste-disposal problem. The question is how can this energy best be utilized.

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Four solar batteries on deck of model provide sufficient power to propel boat through water at speed of three knots.

There are several ways in which solar energy can be—and experimentally is being—converted into usable power. The most obvious, of course, is thermal conversion, the utilization of solar energy as heat. Depending on the requirements and on the conversion devices used, temperatures ranging from below 100 degrees centigrade for water heaters, pumps and distilling devices to temperatures of many thousands of degrees for industrial and research use, are being produced.

Another conversion process involves the transformation of solar energy directly into electricity through use of photoelectric substances such as crystallized silicon. The Vanguard radio batteries fall into this category.

The third and least understood of the major conversion methods involves chemical processes, a category which includes biochemical, biological, and photosynthetic processes.

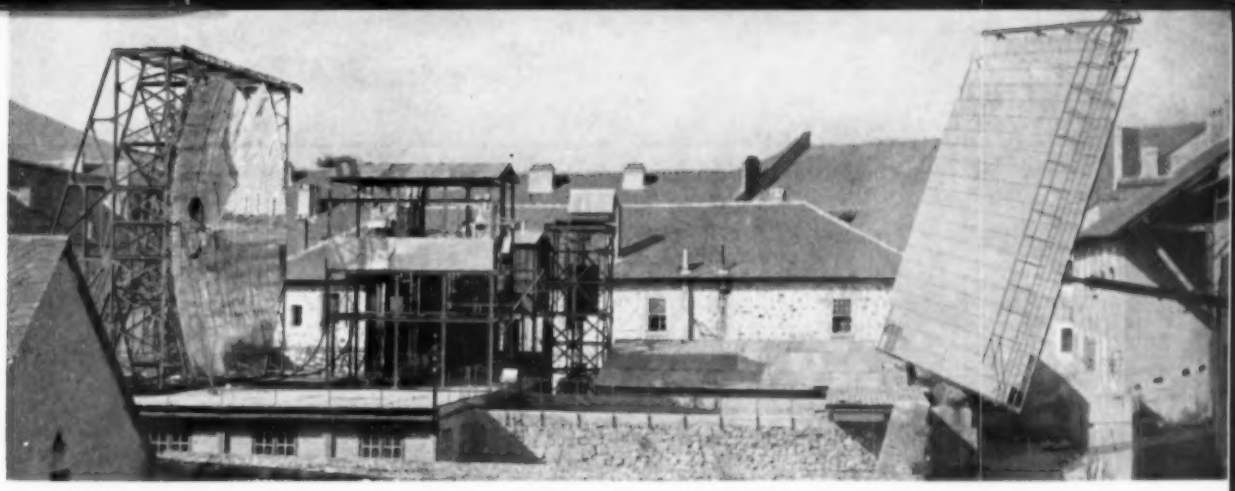
At this stage of solar-energy development the greatest and most "practical" gains have been made in the thermal process—the conversion of solar energy into heat. The most dramatic and useful device currently employing this type of solar energy is the high-temperature solar furnace. Apart from the satellite batteries, this is the only device in which solar energy can do the job better than traditional power sources at this time.

THE principle of the solar furnace is familiar to any boy who has charred a piece of paper by focusing the sun's rays through a magnifying glass. Various types of focusing arrangements have been utilized in solar furnaces. A typical unit involves a heliostat, or sun-reflecting mirror, and a parabolic mirror which collects the sunlight from the heliostat and concentrates it at a single spot, usually an area less than half an inch in diameter. Temperatures as high as 9,000 degrees Fahrenheit—four times that obtained in a blast furnace—have thus been achieved.

In addition to the high temperature, the solar furnace has several other advantages that make it a more useful tool for high-temperature research work than any other type of furnace available. For example, there are no combustion products to act as contaminants, since radiant energy is a pure heat source. Reactions between the material to be heated and its container are eliminated because the material acts as its own crucible. With the solar furnace, peak temperature can be achieved in a matter of seconds or gradually if necessary, since temperature can be controlled at all ranges. Finally, the heating operation can be done in air, in any desired atmosphere, and at low or moderate pressure.

In those areas where the effects of

Solar batteries on crown of helmet provide electrical power to operate built-in transmitter-receiver.



Largest solar furnace, France, consists of heliostat, right, to reflect light, and paraboloid, left, to focus sunlight.

high temperatures on materials must be studied—such as in atomic power piles, jet and rocket engines, and on surfaces during high speed flight—the solar furnace is a research tool without equal.

One of the largest solar furnaces, capable of producing temperatures up to 8,000 degrees Fahrenheit currently is being built in New Mexico by the U. S. Air Force. The heliostat of this furnace will be 130 feet high and 140 feet wide. Major research will center on the study of the effects of rapid temperature changes on metals used in missiles.

Another application of solar energy through the thermal conversion process is the distillation of salt water, a project which, if it becomes economically feasible, may open for use those areas of the world where sunshine and salt water are plentiful, but where rain and fresh water are scarce.

The largest solar "still," built in Chile in 1872, could convert 6,000 gallons of water daily. In this unit, as in many of those of more recent construction, a large flat container is hermetically closed by inclined glass plates and filled with salt water. The solar heat evaporates the salt water, and the saturated vapor inside the container condenses on the inside surface of the glass plate since the temperature of the plate is lower than the inner temperature of the container. The condensed droplets of the now fresh water are then collected in a trough as the water falls from the edge of the glass.

OTHER applications of the thermal conversion process include heating units for buildings (several office buildings and private homes now obtain their heat from the sun), low-temperature pumps, and solar cookers.

Transformation of the sun's heat into mechanical power through the production of steam or hot air offers another challenging, but thus far a relatively unfruitful, application of the thermal conversion process. The major problem here is the intermittency and unpredictability of the power source. Clouds and night, for example, will shut off the power supply.

A practical solar machine, therefore, must include power-storage facilities with the added cost this involves, or it must be used in situations where an intermittent power supply is not a particular handicap, such as in irrigation and in land-reclamation pumping projects.

The Soviet Union has been doing considerable work in this area of solar research and has begun construction of a solar power station in the Ararat valley of Armenia, a station which is expected to generate 2,500,000 kilowatt hours and 20,000 tons of steam a year.

The Soviet power station reportedly will consist of 23 concentric railroad tracks carrying trains of cars on which

Silicon cells convert sun's energy into power for telephone line.

First U. S. solar furnace produces 5,400° F.

are mounted nearly 1,300 mirrors. The mirrors will track the sun and direct the rays onto a movable boiler mounted on a 130-foot tower. Steam generated in the boiler will be piped to a turbine, and the power thus produced will be used to drive pumps for irrigation and for draining swampland. The station will be surrounded by a ring of trees to protect the mirrors from dust.

Those who have experimented with the transformation of heat into mechanical energy suggest that it might be useful as a power source for earth satellites, for in space the variability of the solar energy source is predictable and clouds present no problem.

At a recent meeting of the American Chemical Society it was suggested that the sun might be the source of power for vehicles traveling high in the earth's atmosphere. At an altitude of sixty miles or more, it was pointed out, the large number of oxygen molecules that exist are broken up into their constituent oxygen atoms by the rays of the sun. If these constituents could be made to combine into conventional oxygen molecules—thereby releasing energy—they would represent an unlimited power source. If engines could be developed to compress the oxygen molecules, thereby forcing them to combine and to liberate energy, a new form of propulsion would be available.

THE second major method whereby solar energy is converted into usable power—that in which electricity is the end result—is not so well understood as the thermal process, although striking advances have been made in this area in the past few years. Several devices for converting solar radiation into electric power have been in use for more than a century, but their efficiency has been too low for any but the most specialized uses, such as photographers' light meters, photoswitches, and photoelectric eyes. The real breakthrough in this area came in 1954 when scientists at Bell Telephone Laboratories succeeded in developing a solar energy converter of 6 per cent efficiency, which was later stepped up to 11 per cent.

The Bell solar battery utilizes a series of silicon "sandwiches," one side of each having a free positive charge, the other a negative one. Between the two is a "p-n junction," a built-in electric field formed by injecting impurities into the hollow area. Light energy, or photons, hitting the p-n junction center, force the negative and positive charged particles into matching sides of the silicon sandwich. This sets up a voltage across the sides of the silicon crystal—the source of the electrical power.

Largely through the work of Hoffman Electronics Corporation the silicon solar battery has been given extensive military and commercial application—in radios, flashlights, beacons, telephones, and other devices.

THE six solar-energy batteries in the Vanguard satellite, developed by the U. S. Army Signal Engineering Laboratory at Fort Monmouth, N. J., each contain eighteen silicon cells and are distributed over the face of the satellite so that one will always be facing the sun. About 40 per cent of the time, however, the satellite is in the shade, and therefore without its power source during that interval.

The third major area of solar conversion, that involving chemical processes, is the least understood, yet it is the one that may some day prove—literally—the most fruitful, for success in this area may mean new and improved methods for increasing the world's food supply.

The most familiar and the most important example of this form of solar energy conversion is photosynthesis. Although this phenomenon is far from being completely understood, it is generally agreed that photons of sunlight supply the energy by which—in the presence of chlorophyl—hydrogen atoms are removed from water by carbon dioxide and the two combine to form carbohydrates. On combustion, the carbohydrates give back the carbon dioxide and water and release the store of energy.

Solar energy, therefore, is converted, stored, and released as chemical energy. In agriculture the efficiency of photosynthesis is less than 1 per cent, but under laboratory conditions about 30 per cent of the light energy can be stored and later released by combustion.

At present, most of the experimental work in this area of solar-energy utilization centers on methods for mass culture of Chlorella algae—a low plant form with a relatively high photosynthetic efficiency. Research suggests Chlorella might be useful as a supplemental food source, particularly in those areas of the world, such as Japan, where food-growing areas are limited. Algae have a high food value, equivalent to yeast, and can be grown in otherwise useless areas. Algae studies have provided much information which may some day be used to step up the efficiency of photosynthesis in the higher plants, thus increasing their yield. More important, work with algae provides research data aimed at the ultimate goal in this area of solar-energy conversion—the direct production of food from inorganic raw materials.

What, then, is the future for solar energy, particularly in those areas directly or indirectly related to ordnance?

Two applications of solar energy are of definite practical value right now—the solar furnace for high-temperature research and the solar batteries for the satellite radios. Whether or not solar furnaces will have industrial as well as research utility will depend in large part on whether or not the cost can be brought down.

THE wide use of solar batteries is also dependent on the cost factor, although their use in space engineering seems assured. Other military applications, such as in the helmet radio and airway beacons, seem promising. For general heavy power requirements, however, the solar battery—at least at the present time—cannot compete with existing power sources.

Solar heating of homes (or from the military point of view, of barracks, hangars, and similar installations) must await further improvement.

Solar energy for sea-water distillation and for plant growing are still in experimental stages and will, at any rate, find greatest application in nonindustrialized areas.

Transformation of solar energy into mechanical energy, such as in the Soviet power station, appears to be of value only in specialized areas.

Summing up: the wide application of solar energy, except for high-temperature research and space technology, is at present—or even in the near future—limited. But it should be remembered that just a decade and a half ago the wide application of nuclear energy, too, seemed beyond imagination.

Circuit Reliability

A high state of efficiency has been achieved in a transistor package for the guidance system of an intercontinental ballistic missile by the careful, detailed application of sound manufacturing practices

G. A. Raymond

COMPUTERS with deadlines to meet, computers that must always do the job the first time, must be reliable computers. As new components, new circuits, and new concepts are developed, increased reliability will follow, but real-time computer applications are demanding reliability now—with present components and methods. Concentrated application of available techniques in circuit design and component selection can produce impressive results in improved reliability.

Just how impressive these results can be is best illustrated by the computer developed by Remington Rand Univac for the intercontinental ballistic missile. This relatively large digital machine with 30,000 diodes, 10,000 transistors, and 35,000 resistors is averaging over 200 hours between failures. In 1,000 hours of operation over a 5-month period, only 4 computer failures occurred.

THIS record was achieved not with new components or miraculous new processes but with careful, detailed application of sound engineering and manufacturing practices. This paper is the story of the approach used and the results achieved in the development of the basic electronic circuitry and packaging of this computer.

In recognition of the special needs of the situation, a unique team was organized to develop this computer. Early in the development program, the usual project organization was augmented with engineers trained in quality control, specifications, production engineering, and mechanical design, plus mathematicians and statisticians skilled in the use of computers. Organizational lines were by-passed and a closely knit working group established.

Mr. Raymond is with Remington Rand Univac, St. Paul, Minn. *This article was presented before a recent meeting of the A.O.A. Missiles and Astronautics Division held at Patrick Air Force Base, Cape Canaveral, Fla.*

As development progressed, a special manufacturing department was organized to work directly with the design group so that manufacturing processes would be consistent with the reliability requirements. Much of the success of the program resulted from the close working relationships between the design and manufacturing groups.

The desire to use mechanized design techniques as an aid to the logical design, plus a requirement for simplified maintenance, dictated the use of a small, relatively simple building block. The standard circuit (Fig. 3) uses diode logic with a transistor amplifier. The input diodes function as an "or" circuit, the surface barrier transistor as an inverter or "not" circuit, and the output diodes as "and" circuits.

Direct coupling is used with −2 vdc representing binary zero and ground potential representing binary one. Up to six inputs may be provided. A PNP alloy junction transistor connected as an emitter-follower provides the power amplification necessary to drive the eight possible outputs.

Over three thousand of these basic circuits are used in the computer, some as the basic inverter circuit, and others interconnected to form flip-flops. Altogether, seventy-five per cent of the computer is composed of this one basic circuit.

SINCE so many identical basic circuits are used, it becomes obvious that added circuit reliability could pay large dividends in computer reliability, so a major reliability effort was applied.

Having established the circuit configuration and made the usual laboratory experiments, a program for the Univac Scientific was prepared using the circuit design equations to compute optimum circuit parameters. After establishing criteria for expected parameter variation with life, the values of all parameters were calculated to give the maximum circuit stability.

The results are impressive. Even after the beta gain of both transistors has dropped to two-thirds of the purchase value and the diode reverse currents have increased from 50 to 400 microamperes and all the resistors have drifted 10 per cent in the worst direction, the circuit still will suffer a 10 per cent voltage variation without failure. Thus it has been demonstrated that

careful, detailed engineering will produce reliable circuits that remain reliable as the components age.

The selection of components likely to contribute most to the reliability of the computer also required a comprehensive program. The decision to use transistors rather than vacuum tubes or magnetic core switches resulted from an extensive investigation during which several small self-checking computers were built and operated. Substantial quantities of all types of components were subjected to heat, humidity, shock, vibration, low temperatures, and other destructive environments that might contribute information on comparative component reliability.

Particular care to detect a tendency toward catastrophic types of failure was necessary in this investigation. Components that deteriorate gradually with time would be detected and removed before failure occurred, while catastrophic failures would mean circuit failure every time.

The final decisions on component choice had to be based on reliability and not electrical characteristics. Every engineer had to put reliability ahead of all other design requirements, and circuits had to be redesigned to use less efficient components where these proved to be more reliable.

Having established those components that were to be used, it became necessary to establish controls to assure that only these components would be used in manufacture of the equipment. Specifications were written covering every critical component with quality-level requirements exceeding the most rigid military specifications. Large samples drawn from every lot of components had to be subjected to rigid acceptance tests at the manufacturer's plant and again at Remington Rand Univac.

To ensure compliance with the specifications, Univac quality-control representatives are stationed at each manufacturer's plant during the production and testing of the components.

THE final assurance that only reliable components are used is the complete test of every component prior to introduction into the computer. In most cases this test is performed on specially designed automatic machines such as a transistor tester.

This unit, with a turntable arrangement, moves the transistor through a number of test stations. The test circuitry and parameters to be measured at each station are programmed on a plugboard at the upper right. Counters at the upper left record the rejects on each separate test while the components are being sorted into "accept" and "reject" categories.

Fig. 1. Standard package showing results of selective soldering.

Extreme precaution had to be taken in the design of the test machines so that transients or equipment failures would not cause damage to the components being tested. This is extremely important in the case of surface barrier transistors where even small transients may cause complete failure.

Continuous improvement of final screening tests is an important area where much can be done toward eliminating the "weak sisters" from component lots. Improvement of these tests is continuing as results from a large-scale component-testing program are received. This program is being conducted by Inland Testing Laboratories in Chicago, Ill., and Battelle Memorial Institute in Columbus, Ohio, and will give life characteristics and data for screening tests on transistors, diodes, and resistors used in the computer. Approximately 60,000 components are on test in this program.

Many of the components tested during the development program showed tendencies toward deterioration under certain environmental conditions. High humidity proved to be the worst offender, and complete protection of the components from humid atmosphere showed prospects of improving reliability. The results of this phase of the design effort are perhaps the most unique of all the work done to achieve greater reliability.

A specially designed connector mounting two etched circuit boards is the standard package for all electronic circuitry in the computer, and all circuits are mounted in this fashion. The package design, shown in Figure 2, provides positive hermetic sealing. Connector pins are brought out through glass-to-metal seals in the base, and a pressure valve is provided for pressurizing the chassis with dry gas.

The seal around the base is made by induction soldering and may be unsoldered for repair of the circuitry. The manufacturing process includes a complete bake-out of the chassis under high vacuum to reduce the relative humidity below one per cent after sealing. The relative humidity may be checked by means of a humidity-sensing element mounted inside each chassis.

The highly reliable contact arrangement is reminiscent of the knife switch used in power circuits with a flattened male pin and tuning fork-shaped female contacts. Two completely independent pairs of contacts in the female connector give redundancy for added reliability. Of the 100,000 contacts in connectors used to date, not one single case of poor contact has occurred.

THE etched wiring boards mounted on the connector are fiberglass-epoxy laminate with rolled copper foil on one side. Extreme care is observed in selecting and processing this material so that the finished boards are completely free of scratches, pinholes, or other defects such as warpage or contamination. Assembly of the entire chassis is a "clean-room" operation with temperature and humidity control, white smocks and gloves for all operators, and strict process control.

Policy prohibits touching any component with the bare hands. Any component that is dropped, even in a container, is rejected. Rework is carefully controlled and strictly limited. Complete records are kept of each operation on each unit including the time, date, and operator number so that assembly reference can be made during the routine analysis which follows every failure.

Dip soldering is used to attach the

component leads to the etched wiring and also to connect the etched wiring to the connector pins. These two separate operations are performed on a selective soldering machine which permits masking the entire circuit and exposing only the areas where solder is desired. This procedure reduces the heat transfer to components and permits attaching the components to the board in one operation and the board to the connector in a following operation. The results of selective soldering are shown in Figure 1.

Following the dip soldering and prior to an electrical test, the completed board is given a temperature shock from room temperature to +155 degrees and then to −50 degrees Fahrenheit. The temperature shock treatment is further insurance against marginal components or connections that might later show intermittent failure.

Final assembly of the sealed chassis includes pressurization with a mixture of nitrogen and helium thus allowing a standard helium leak detector to be used for checking the final seal.

With the final seal complete and final electrical checkout satisfactorily performed, the chassis is installed in the computer panel as shown in Figure 4. Insertion is performed with a special tool to prevent damage to the connector pins. The chassis is fastened in place with hold-down screws and is ready for operation.

The purpose of this paper has been to present a broad picture of a reliability design effort that achieved true reliability. The salient points may all be summarized in the one word—attitude. The desire for reliability must be present in the mind of each person from the chief engineer to the girl on the assembly line. The finest quality control cannot make a poor design reliable and the finest design will not be reliable if the person who builds it is careless.

Careful attention to minor details in the selection of components, the design of the circuitry, the packaging of components, and the manufacturing process can pay off in a big way where reliability is the most important requirement.

The Missiles and Astronautics Division of the American Ordnance Association, formerly the Guided Missile and Rocket Division, is continually coöperating with the armed forces on similar problems.—Editor.

Fig. 2, above, hermetically sealed unit with vacuum tube for comparison.

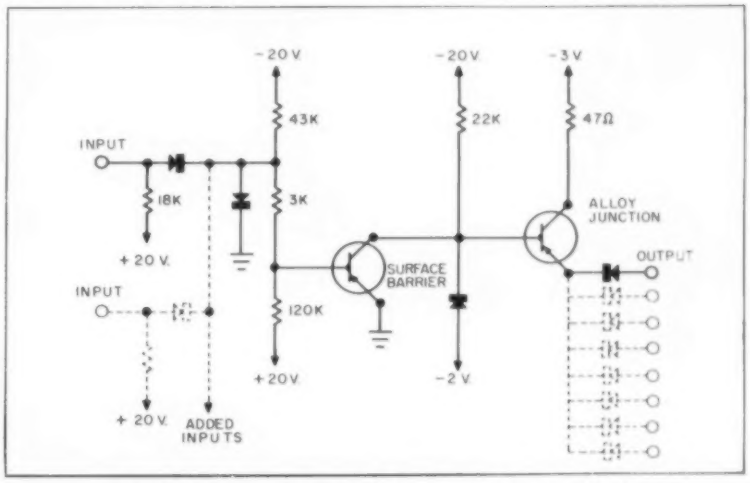
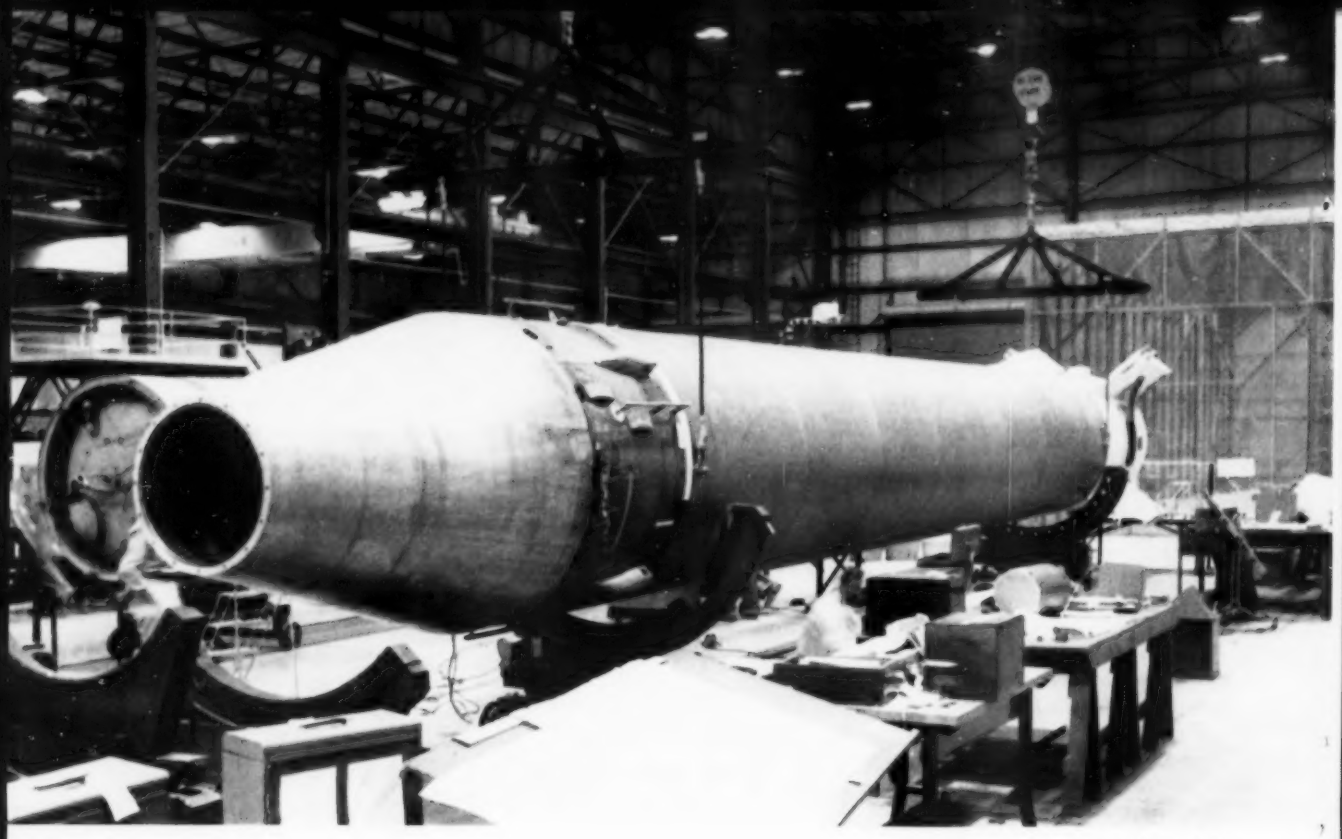


Fig. 3, above, standard circuit for computer building block.

Fig. 4, below, completed packages installed in computer rack.



(Army photo)

Building the Jupiter-C

Melvin C. Duke

THE 200-mile range Redstone ballistic missile, the new workhorse of the U. S. Army field artillery, is fabricated to tolerances within thousandths of one inch. The aluminum ballistic shell in particular is built with the same precision given an expensive watch.

In addition to building ballistic shells for the Redstone missiles, Reynolds Metals Company has built complete shells for Army Jupiter-C rockets at the firm's missile plant at Sheffield, Ala.

Fabrication of ballistic shells for the Jupiter-C is similar to that for the Redstone missile. In fact, the first stage of the Jupiter-C is a modified Redstone. However, these modifications complicated the construction process, and tighter tolerances were required on the Jupiter-C.

Working directly under the Army Ballistic Missile Agency at Redstone Arsenal, Ala., company technicians built several complete ballistic casings for Jupiter-C rockets. These included the tail section, the center section (with fuel tanks), the nose section for the first stage, and the unique spin-launcher for the upper stages.

One of the Jupiter-C ballistic shells made by Reynolds was used on the rocket which on August 8, 1957, successfully tested a nose cone. President Eisenhower, displaying this nose cone during his nationwide television address in November 1957, explained that it had gone hundreds of miles to outer space and returned intact. This test solved the difficult problem of preventing an object from burning up when it reënters the dense atmosphere of earth.

Building the ballistic shells for the space-conquering Army Jupiter-C posed some knotty problems. For example:

The nose section of the main stage was formed from thin aluminum sheets welded together. In order to put these sheets together in the exact tapered design, company technicians had to work with tolerances far more precise than those the Army scientists had demanded.

Once the sheets were put on the automatic welding machines—operating at a speed of sixty inches a minute—everything had to be absolutely perfect. If the welding machine missed a gap in the joint, the parts were rejected and the job started all over again. No weak points were tolerated in the welds.

The nose section had to withstand rather high pressures and yet remain airtight. When tested under pressure, the

thin sheets actually could be seen ballooning out. Yet all the welds held tight.

The spin-launcher, which gives gyroscopic stability to the upper stages of the Jupiter-C when they are fired, also had to be fabricated to exacting requirements. The launcher bucket which holds the upper stages was constructed from two sheets of aluminum, rolled to form a cylinder and then welded along the length.

These welds, each forty-eight inches long, had to be absolutely perfect. No repairs were permitted. Once the high-speed automatic welding machine had started, it could not be stopped. If the machine passed over a gap in the joint, the cylinder had to be rejected.

When the Jupiter-C started to blast off, this bucket was rotated by electric motors mounted within the nose section of the main stage. The gear system which actually spun the bucket also was built to precise tolerances. The spinner wheel had to fit exactly and revolve on its shaft, otherwise the upper stages could have been thrown off course when fired.

THE proximity of the Reynolds missile plant to the Army Ballistic Missile Agency facilitated development of both the Redstone and Jupiter-C ballistic shells, as company technicians were able to confer at a moment's notice with the Army scientists.

The company technicians worked from marked-up blueprints while building the Jupiter-C shell. Within

Mr. Duke is manager of the Reynolds Metals Company missiles plant at Sheffield, Ala.

days after the scientists modified the shell design, the changes were incorporated into the finished product. And these changes kept coming during the entire construction time.

Our company is just one member of the industry team which supplies components for the Redstone ballistic missile. The prime contractor, Chrysler Corporation, Detroit, assembles the components and completes the finished weapon. Ford Instrument Company, a division of Sperry Rand Corporation, Long Island City, N. Y., builds the instrumentation system. North American Aviation Corporation, Los Angeles, manufactures the rocket motor.

Reynolds employs one inspector for every four technicians working on the rocket casings. Each of the more than 20,000 parts which go into the aluminum shells is inspected one or more times both for its operation and for its physical quality. All these inspection records are shipped with the completed ballistic shell.

Each stage of assembly is checked before it is joined to another stage to form a larger structure. This saves tearing down large pieces of the missile shell if some minor piece shows a weakness.

Although this might appear costly, in the long run it saves money. No chances can be taken with these huge missiles. If one of these rockets should misfire, it could cause the loss of hundreds of thousand of dollars.

Quality control actually starts when the aluminum sheet and plate arrives at our missile plant. These sheets must be perfect. Inspectors check the incoming metal for scratches or blemishes. They use electronic instruments to search for possible weak spots which might fail under pressure.

THE width and thickness of each sheet is then measured to tolerances within a few thousandths of an inch. These sheets, mainly alloy 5052 and 5086, have a mill-rolled finish and are stretcher-leveled.

Samples of each lot are sent to the laboratory for chemical analysis. Each sheet and every other part are assigned lot numbers in the receiving department. A complete history is kept of every single piece that goes into each missile.

After each aluminum sheet passes this rigid inspection, it is covered with protective tape (No. 343 3M) which comes in 30-inch-wide rolls. This is done on a special table equipped with three rolls of tape to cover the 90-inch wide sheet of aluminum. This protective paper stays on the sheet all through the assembly process, protecting the surface from dirt, scratches, and fingerprints. Only when the final assembly is ready for cleaning and finishing is the paper removed.

The aluminum sheets (5052 alloy)

Workmen assemble aluminum tail sections of the Jupiter-C missile which will hold the powerful first-stage rocket motor.

Spot-welding part of Jupiter-C center section fuel tanks. Each fuselage has 24,560 such welds.

are trimmed to length—220 inches—fitting a tolerance of 0.002-inch. Both ends are trimmed square with the edges of the sheet by high speed cutter heads operating at 50,000 r.p.m. on both sides of the trimming table. Simultaneously a bevel is cut along the ends for later welding.

The trimmed sheet is rolled to form a cylinder. Then the ends are welded on an automatic welding machine.

THIS aluminum sheet has now become a "shell" which is strengthened by spotwelding an aluminum reenforcing bar (5052 alloy) along the longitudinal weld.

The shell now goes to a horizontal mill designed by Reynolds engineers. Here the shell is trimmed to exact length, fitting a tolerance of plus or minus 0.015-inch. This trimming also parallels the edges. Aluminum stiffener rings—shaped on a radial draw forming machine—are then spot-welded into the shell. Approximately 24,000 spot welds are made on a Redstone missile ballistic shell.

Eight shells—varying from twenty-four to sixty inches in length—are used to form the fuel tank or center section of the Redstone missile. This 34-foot long center section has to meet a tolerance of 0.031-inch. This section is built from three subassemblies: the front, consisting of the alcohol tank bulkhead and two shells; the center, with a bulkhead and four shells; and the aft, with two shells and the rear bulkhead for the liquid-oxygen tank.

Bulkheads are fabricated from 90-inch square sheets of 5052 aluminum which are drawn into domes. This is done at the company's Louisville, Ky., Plant 12 on a 1,700-ton, double-action press utilizing a 12-foot bed. The missile plant in Alabama uses a special jig to cut holes in these bulkhead domes while flanges are extruded with a hydraulic draw bar. Then a router on the jig trims the dome to correct depth.

The fuel-tank bulkheads are spot-welded in the shells, the edge of each head positioned flush against the shell edge. Thus when the shells are welded together to form the sub-assemblies, the bulkheads are also welded and completely sealed.

The shells forming three subassemblies of the center section of the Redstone are welded together, end to end, along their circumference on an automatic machine operating at an average of twenty-five inches a minute. However, this varies with the thickness of the metal. Here the Sigma process is employed with a metallic arc working in argon or another inert-gas atmosphere.

WATER cools the welding head. Number 4043 aluminum alloy wire is used as the welding rod. Stainless-steel backup bars clamped inside the shell are grooved to shape the bottom of the weld bead. The machine is set usually at 250 amperes at 20 volts.

Before the automatic welding machines are started, technicians run a test weld in a special jig. This weld is then X-rayed and tested for strength to make certain that the welding machine is in perfect condition and the settings correct for the particular alloy being welded. Only after the laboratory gives an O.K. does the welding start.

The ballistic shell for the Redstone missile contains more than 12,000 inches of welds. Every single inch of this welding is X-rayed, some more than once, to make sure no weak spots exist. At least 1,600 sheets of X-ray film are used to examine these welds.

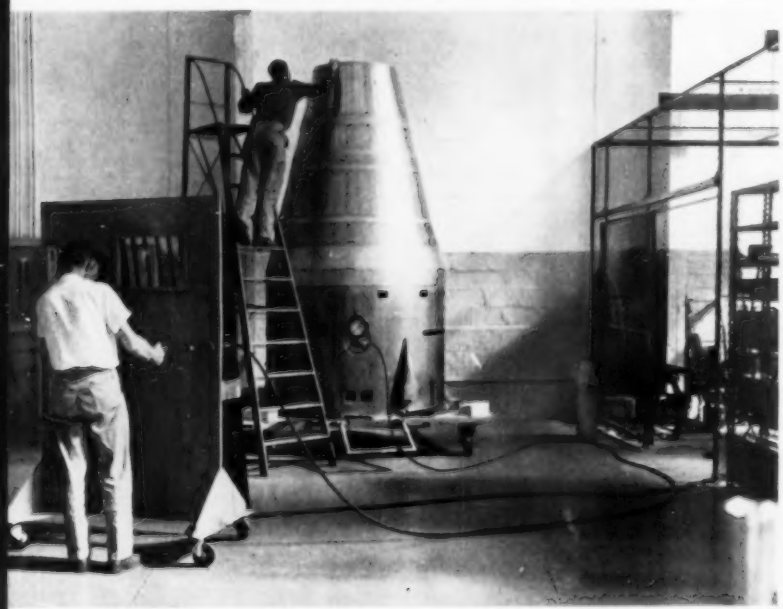
When porosity is found in a weld, the bad section is routed out. Then the surrounding area is again X-rayed to make sure the porous section is all cleaned out. After hand-welding the routed part, another X-ray is taken. Duplicate copies of each X-ray film are shipped with each finished ballistic shell.

THERE never has been a single case of a Redstone missile failure due to poor welding.

While it takes approximately 10 to 12 minutes for the machine to weld the 220-inch girth of the shells, it takes as long as 3 hours to set up for the weld. Technicians scrub the welding area with steel brushes, then wipe it with cloths dipped in trichloralethylene. The biggest enemy of the welding is skin oil from fingerprints or specks of dirt which could cause porosity. This is one reason why the missile plant is kept as clean as a fussy housewife's kitchen.

Technicians compare automatic welding with launching a missile—once it starts there's no halting it. Once the automatic welder has started, it is never stopped until it has gone all around

Technicians prepare to air-test main-stage nose section. Made of thin aluminum sheets welded to precise tolerances, this section must be airtight.



Inspector checks spin-launcher atop nose section in final assembly stages of Jupiter-C.

the shell circumference. In the Reynolds plant, when the automatic welder starts, a red light warns the crane operators to keep their machines shut off. To prevent power fluctuations from ruining the weld, technicians never weld when they know the blowers in a neighboring foundry are ready to start up—usually at 2:30 in the afternoon.

Complete information on each weld is written on the protective paper covering the shell. This includes the date, time of day, and weld number. When checking the X-rays against the welds, this facilitates locating spots which have to be rewelded.

To connect the nose cone and the tail section of the Redstone missile to the center section, heavy rings are riveted to the front and rear ends of the fuel-tank section. These rings are formed from a Z-section and two angles.

At this stage, aluminum pipes are installed inside the fuel tanks. Built as subassemblies of the center section, the piping is designed to carry liquid oxygen and alcohol as well as wiring. The piping is welded into place on flanges extruded on the tank bulkheads and to brackets on the skin of the tank itself.

THE electrical conduit has a 6-inch diameter and must carry a full load of wiring. Therefore the weld build-up at the joints is held to the minimum to make room for cables.

Air pressure is used to test the piping and fuel tanks for leaks. Then the 34-foot-long fuel-tank section of the missile is raised into a vertical stand for hydrostatic testing. The top tank is filled with three feet of water to which is added a fluorescent dye. An inspector climbs into the bottom tank and checks the bulkhead with a black light. If there is any leakage, the black light will detect it.

Then water is pumped into both the liquid-oxygen and alcohol tanks to measure their exact volume. Later the water is pressurized to make sure the welds and the skin itself can withstand strong pressures when the missile is fueled and launched.

All during fabrication of the fuel-tank subassemblies the various parts are repeatedly examined in the optical inspection dock. This 40- by 23-foot chamber is used to check the alignment of all assemblies. Outside dimensions are inspected to make sure the shells are straight, that mounting holes are precisely placed, and that the engine mounting pads are in the right location.

The tail section for the Redstone missile is built from aluminum alloy 2024. A rubber-pad press is employed to shape stiffener rings, then skins of alloy 2024 are riveted to the rings.

Tail fins—which are attached to the skin—are made by riveting sheet to press-formed ribs. A base of stainless steel, type 301, made of flat plates and reenforcing brackets, is riveted on the tail section. The stainless steel protects against the heat of the rocket motor.

A special fixture, designed and built by company engineers, provides positive alignment of tail fins and rudder housings during final assembly. Rudder-drive housings and fins with bearings for rudder-drive bars are installed on this jig. The rudder-drive housing has 110 dimensions which have to be inspected, many of them more than once.

The rudder torsion bars, built from aluminum, connect the rudders with the steering mechanism and have to meet the most exacting tolerances.

Aluminum castings from alloy 220 are installed on the bottom tips of the fins in the shape of pads on which the missile rests when in firing position. Other aluminum castings are employed to hold together the major sections of the entire missile. Each casting is X-rayed and pieces tested for tensile strength, elongation, and chemical analysis.

At the final finishing department, the fuel tanks are vacuumed, then hand scrubbed three times. For eight hours the center section revolves on a platform while trichloralethelyne washes the tank chemically clean. Samples of the cleaning agent are repeatedly taken and analyzed until it is approved by the inspection department. After air-drying, the tanks are sealed to keep them pure.

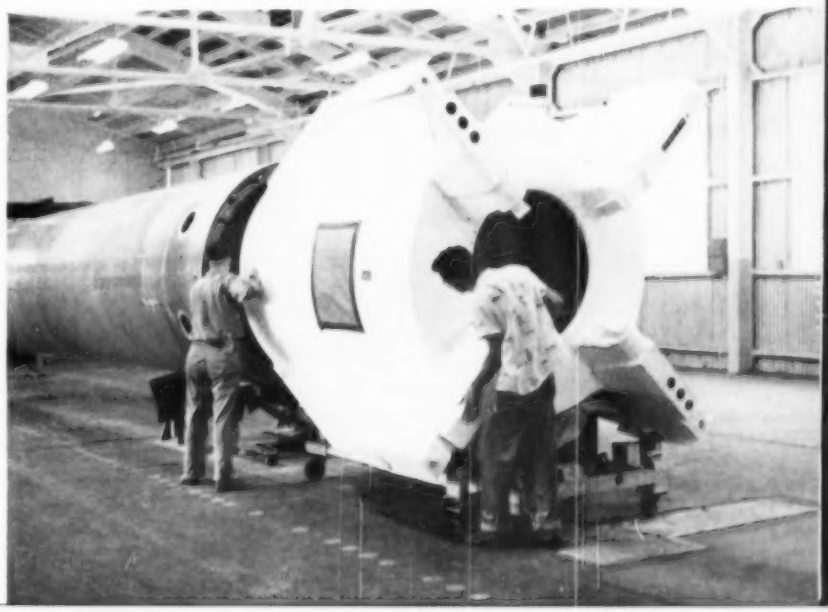
Why so fussy? Because a particle of metal shaving or even a speck of dirt could cause an explosion when the liquid fuel is eventually pumped into the tanks.

WHILE the fuel tank is revolving on the fixture, technicians are removing the protective paper and scrubbing the exterior of the shell with a detergent.

The completed Redstone ballistic shells are shipped to the Detroit plant of the Chrysler Corporation. There Chrysler assembles the rocket engines and guidance systems with the shell casing. The only automobile manufacturer engaged in ballistic missile production, Chrysler made important contributions to the Jupiter-C rocket used to launch this country's first space satellite on January 31, 1958.

Reynolds got into missile fabrication in 1952 when the Army assigned company technicians the job of redesigning the Redstone ballistic shell so it could be produced in quantity. Company experts took the Army design and adapted it so the missile casing could be manufactured in volume using available machinery and standard shapes.

Workmen wheel missile tail section into place behind center section of the Jupiter fuselage.



Rearming at Sea

New Navy ammunition ships and modern methods of storing and handling have speeded up the transfer of material while underway on the high seas with great improvement in the fleet's replenishment potential

Harvey C. Simms

THE Navy has responded to the challenge of faster fleet rearming at sea by developing a new class of ammunition ship.

The problem of maintaining our fleet at sea for long periods has become increasingly complex, and in face of present world tensions the necessity of well-supplied naval forces is of major importance in deterring aggressions and acting as a retaliatory potential. Rearming at sea is a vital cog in the logistic pattern of supplying the fleet, and the Navy is continually developing methods to improve the speed and safety of transferring ammunition and guided missiles while under way.

A major contribution in this area was the commissioning of two new ammunition ships, the U.S.S. SURIBACHI (AE-21) and the U.S.S. MAUNA KEA (AE-22). These ships contain many new features to improve ammunition handling and, in collaboration with a widespread program to palletize a major portion of ammunition aboard, have increased transfer rates substantially.

THE concept of replenishment at sea is entirely naval; nowhere in civilian sailing can we find anything to compare to it. Theoretically, ships may remain at sea for the entire period between major overhauls or drydocking. They may be refueled by fleet tankers and receive repair parts, munitions, clothing, and food from ammunition and supply ships. This process was carried out extensively in Korea where nearly all combatant ships were rearmed while on the line.

Mr. Simms is with the Cleveland Container Company, Washington, D. C. This article is based on a report presented by Mr. Simms before a recent meeting of the A.O.A. Container Committee of the Bomb and Artillery Ammunition Division held at the U. S. Naval Ammunition Depot, Earle, N. J.

In November 1951, the Chief of Naval Operations initiated a project to improve handling and stowage of ammunition aboard AE's. Before discussing the innovations resulting from this project that were incorporated in the SURIBACHI-class ship, let us review the history of transfer at sea and the basic factors that contribute largely to the success or failure of these operations.

The first significant replenishment performed by the Navy took place in 1899 between the U.S.S. MARCELLUS, a collier, and the battleship MASSACHUSETTS. The MASSACHUSETTS towed the collier and received coal from astern. Fourteen years later, still using the astern-towing method, the Navy had increased its rate of coal delivery at sea to four times that attained in the 1899 trial, although this method did have the obvious disadvantage of utilizing only one line.

Since then the alongside method has evolved, and it is now possible to use five transferring lines over either side at one time. In this method two or three ships steam side by side at 10 to 15 knots, separated by a distance of 60 to 120 feet and transfer ammunition, supplies, or fuel over the side. The inherent danger of collision when two ships cruise abreast of each other at close proximity and the vulnerability of two ships trussed together with a very complex arrangement of transfer, fuel, and telephone lines creates a necessity for high transfer rates and minimum alongside time.

There are six factors that contribute largely to the success or failure of replenishment at sea and greatly affect the transfer rates. These factors are: weather, station-keeping, advance breakout, speed of clearing receipt area, type of cargo, and density of cargo.

THE factors which are significantly affected by the features of the new ammunition ships are advance breakout and speed of clearing the receipt area. The two concerned are benefited by the new methods and equipment which promise to increase transfer rates dramatically. First, let us consider the major innovations in the new ammunition ships and then, by comparing them with the older AE's, show how they are utilized to effect significant time savings.

The changes are: (1) palletized ammunition in significant quantities, (2) metal portable reusable dunnage and web-strapping tomming-down gear, (3) fork-lift trucks and hand pallet movers, (4) nonsparking and non-skidding decks, and (5) split elevators capable of working two different levels at one time in holds Nos. 2, 3, and 4.

Advance breakout was necessary in the older ammunition ships because the below-deck breakout rate was materially slower than the transfer rate so that a large percentage of the ammunition to be transferred was broken out in advance and temporarily stowed on the main deck. This was unsatisfactory because the ship was extremely vulnerable to a strafing attack, and a sudden turn of bad weather could result in the hazardous condition of loose ammunition rolling about. Nevertheless, this condition was prevalent in all the previous major transfers.

THIS advance breakout problem has been eliminated by the aforementioned features which have improved ammunition-handling methods to the point where the rate of breakout of material and delivery to the transfer area now exceeds the transfer rate. This allows the ammunition ship to begin transfers with relatively clean decks.

The elimination of advance breakout is directly attributable to at least four major types of the SURIBACHI's new equipment. The breakout from stow is expedited by the relatively simple operation of removing the portable dunnage as contrasted with the slow procedure of dismantling bins of ammunition boarded in with wood dunnage.

Once the stanchions are taken out, removal of palletized ammunition is much faster than the old method of stacking loose items in a skip box standing on the square of the hatch. A pallet load of some 50 cartridge tanks may be moved to an elevator in a matter of seconds where it took five or six minutes for a chain of men to load that many tanks in a skip box.

Speed of the elevators in bringing the load to the main deck is not of primary importance, but the elevators allow working more than one level in a given hatch which increases the selectivity of ammunition or the "supermarket" aspect that is such an important feature of this ship. Main deck movement then is accomplished efficiently by fork trucks or hand pallet movers.

CLEARING of the receipt area is most critical on the smaller ships, such as destroyers and destroyer escorts. If the receipt area cannot be cleared quickly, the transfer hook must wait until either the load has been removed or a skip box is unloaded and returned empty. Maximum transfer rates are possible only if the transfer hook is constantly moving with payloads, because any delay tends to negate the improved handling cycle on the ammunition ship.

Provided maneuvering room is available, the combination of palletized ammunition and power or small mobile hand equipment on the receiving ship accelerates clearing this area and allows continuous transfers. This ammunition is removed to a temporary stowage point where the receiving ship's crew may strike down palletized loads when time permits or, in the case of ammunition in skip boxes, strike down before completion of the replenishment. This is necessary because skip boxes must be returned to the ammunition ship for future transfers, but pallets and accessories may be jettisoned, leaving no trace of the operational area.

A series of evaluation transfers were conducted to test the replenishment capability of the U.S.S. SURIBACHI. The transfers, which covered the majority of ammunition presently operational in the fleet, as well as several guided missiles, included a destroyer, an aircraft carrier, and the latest of the Navy's guided-missile cruisers, the U.S.S. CANBERRA.

Technical personnel who were instrumental in evolving the new system were present as observers and advisers on all phases of this evaluation. They included representatives of the Bureau of Ships, who designed the fork trucks, portable dunnage, and elevators; of the Bureau of Ordnance, who conceived the weapon-handling system; of the Naval Ordnance Materials Handling Laboratory, who designed the pallet loads and pallet sling; and representatives of industry who collaborated with all three groups.

All transfers showed significantly improved tonnage rates, and, although relatively small quantities of ammunition were transferred, the projected rates are considerably higher than the fastest transfers during the Korean conflict in addition to being safer. None of these transfers required advance breakout. At all times the hold-to-transfer-area cycle was fast enough to keep pace with the transfer hook, the receiving ships were able to clear their receipt areas expeditiously with hand pallet or fork trucks, and personnel on both ships showed a preference for handling palletized loads in lieu of skip boxes.

THE Navy, in its attempt to improve the replenishment potential of the fleet, has contracted to build more new ammunition ships in addition to converting older AE's that will incorporate the experience gained in this evaluation and will further improve ammunition and missile handling.

The Navy's new ammunition ship, SURIBACHI, has many modern handling devices.

Missile Reliability

The application of engineering evaluation methods to the Titan weapon system seeks to improve reliability by predicting modes of failure and establishing fixes that will prevent reoccurrence

John D. Prock

THIS paper presents a method for applying reliability study techniques to missile system development. A reliability study is the systematic application of engineering evaluation methods to improve reliability by predicting modes of failure, and the use of these predictions to establish fixes that will prevent failure occurrence or reoccurrence.

This article gives an outline of the reliability study program used at the Denver plant of the Martin Company as part of its efforts to develop the Titan intercontinental ballistic missile, with suggestions of how to implement a program of this type at other facilities and for other missile systems.

The basic objective of missile system manufacturers is to produce a mature, reliable system in the shortest time and at the lowest possible cost. The key words in this objective are "reliability," "time," and "cost." Since these factors are closely interrelated, we can reiterate our objective as a desire to achieve the most efficient balance of these parameters.

THIS article presents a method for applying reliability study techniques to system design, development, and manufacture to improve this balance.

A reliability study can be likened to the stress analysis of a structural design. Its difference lies in the sophistication of the analysis to include environmental effects, manufacturing techniques, inspection procedures, and testing cycles.

Mr. Prock is group engineer, reliability engineering test and reliability section, the Martin Company, Denver, Colo. This paper was given as a report to a recent meeting of the A.O.A. Missiles and Astronautics Division.

In general, it can be considered as an engineering evaluation, based on past and predicted performance, conducted at all stages of missile system manufacture to predict modes of equipment failure.

The cost of implementing a reliability study program depends on the detail with which the study is conducted. Naturally, a very detailed study will be expensive, while a less-detailed study will be proportionately less expensive. Experience of the Martin Company—prime contractor for the Titan intercontinental ballistic missile—indicates that the desired effort on a given item should be gaged by the complexity and cost of the item. As a rule of thumb, the study cost should compare with the cost of one or two of the items.

Normally, an equipment will achieve adequate reliability after several cycles on the reliability improvement curve. However, since each cycle is an investment of time and money, the achieved degree of reliability may be lower than desired to maintain the parameter balance. It is the possibilities for increasing the slope of this curve (*i.e.*, making greater reliability advances with fewer cycles) that make the reliability study program attractive.

How can a study program short-circuit the design-test-evaluation-fix cycle of the reliability improvement curve? The answer to this question can be found in our general description of this program: the compilation of records on past performance, the prediction of modes of equipment failure, and the application of engineering evaluation to planning manufacturing techniques, inspection processes, and test programs.

BEFORE analyzing how each of these factors help to increase the slope of our reliability improvement curve, let's take a brief look at present techniques and procedures used in the industry to help obtain greater reliability. The reliability study will help make sure these techniques are used to the best advantage.

To achieve greater "built-in" reliability and thereby effect time and money savings, missile-system manufacturers encourage their designers to use company and military standard equipment.

The use of these items, since most have been thoroughly tested under controlled environments and operational conditions, also permits the designer more accurate design margins of safety than prototype equipment. The use of standard manufacturing and quality-control processes adds to the reliability achievable with the part.

Added assurance of part and com-

ponent reliability is also achieved by conducting qualification tests on parts and components. In most instances this is a supporting function to determine more closely safety limits and design characteristics for parts that have not yet achieved standard-part status. Qualification testing is a significant contractual item since it may be a condition for acceptance.

FOR material produced on contract for the military, many military specifications help the designer obtain improved reliability for his system by specifying standard environmental conditions, suggested and approved materials, etc.

The use of quality-control inspection techniques to ensure compliance to design, is another aid to reliability. Careful checks of suggested manufacturing techniques help to "weed out" failures due to unreliable material handling and construction methods.

Production environmental testing is a comparatively new and controversial quality-control technique for reliability control and improvement that permits determination of certain environmental failures before fabrication has been completed.

Through an organized method for failure reporting, additional information on modes of failure can be compiled. Since reliability improvement is dependent on the determination and prevention of modes of failure, the importance of this technique is obvious.

The testing-to-failure technique is another means of compiling data on the modes of failure. In addition, by testing to failure we are able to determine actual safety factors for designed equipment.

I HAVE stated that the results of a reliability study program are the compilation of performance data, the prediction of modes of failure with consequent "action item" indicators, and the application of systematic engineering evaluation to all phases of system design and production. I have further indicated that these results help increase the slope of the reliability improvement curve. I will support this conclusion by examining the methodology of the reliability study and relating these methods to our objectives.

Since any study is, primarily, a result of careful "on-paper" analysis, it is evident that any results will produce a data collection. Therefore, before analyzing the importance of the data collected, or how they are useful for reducing the number of the reliability improvement cycles, let us examine the type of data used for the reliability study.

In general, improved reliability is the result of the determination of modes of failure and the analysis of the failure to initiate a fix. Consequently, reliability improvement can be paraphrased as a search to eliminate causes of failure. To this end the value of a well-designed test program to speed up the determination of modes of failure is obvious. It is certainly much more economical to find failures during test than during operational use. However, it is still more economical to predict failures than to find them by testing.

This concept, the prediction of failures *before* testing is the key to the reliability study, and its chief asset for increasing the slope of the reliability improvement curve. Consequently, the focal point of this paper is not *who* performs the reliability study but *how* a reliability study can be initiated.

THE first step in developing a reliability study for a missile system is the division of the system into logical portions for separate study. From experience gained at Martin-Denver and its subcontractors, this breakdown should follow the missile's subsystem and component breakdown.

Again, drawing on our experience, this will result in 150 to 200 separate reliability studies. Fortunately, some of these items may be considered "standard building blocks" (*i.e.*, an item that does not require further reliability improvement) and may be dismissed.

However, if the use of these "building blocks" is extraordinary, or their interface presents unproved performance problems, they should be evaluated.

Once decided on a reliability study item, the requirements for the unit should be reviewed. These include performance requirements, environmental requirements, and reliability objectives. The reliability objective may be specified as a mean time or number of cycles between failures or, conversely, as the probability for satisfactory operation during a given time period or cycle.

Next, the item should be reviewed to establish the function of each subassembly associated with it and to establish the environments and stresses under which these separate subassemblies will be operating. Each of these subassemblies, in turn, should be analyzed further to determine design features.

The term "design feature" connotes a portion of the equipment, and critical aspects of its assembly and inspection. Equipments working in unison or having interface surfaces should be treated separately and in conjunction.

THE detail to which an item is divided into design features will depend on the detail of the study desired. For example, a reliability study of a missile control system might consider a gyroscope as a single design feature. A study of a gyroscope, however, might consider bearings, solder joints, stator windings, or any other part, manufacturing process, or inspection test as design features.

Normally, the original breakdown will be revised to give greater detail in potential or actual trouble areas. The following enumerated points, however, are general guides for the design feature breakdown.

1. Each electronic part should be listed separately.

2. Solder joints should be listed; however, each joint does not have to be treated as a separate design feature. The joints can be grouped as one feature as long as the total number are listed.

3. Items such as bearings, poppets, butterflies, blades, shafts (except as detail parts of an electronic component part), springs, seals, bellows, castings, etc., should each be listed as separate design features.

4. Packaging and wiring harnesses should be listed separately.

5. Critical aspects of assembly and inspection should be included. Again, however, it is not necessary that each be listed separately.

6. Standard building blocks may be considered as design features. However, data should be included to justify the item's classification as a building block.

7. When several parts are joined to form a subassembly, the subassembly should be listed as a design feature although each part is considered separately.

When the list of design features is

complete, all essential elements of the equipment should be included. In addition, each design feature should be identifiable to a drawing or schematic.

The reliability study reporting sheet used should be set up to work most effectively with the specific item of equipment involved. Specific formats were devised by Martin-Denver for use with electromechanical, electronic, and fluid flow or mechanical equipments.

Perhaps the most important single item on all the work sheets is the space provided for recommended action. The items listed here (action items) may include recommended design changes, changes in manufacturing processes or inspection procedures, and suggestions for evaluation test programs.

IF any of the indicated action items will require additional funds, this should also be noted. We are interested in the balance, not the perfection of one factor at the unjustified expense of all others.

Another important area of the work sheet is the space provided for listing modes of failure. It is in this area where the reliability improvement cycle can begin by highlighting probable failure areas. Also, it is from this area that action items to expedite fixes are taken.

The modes of failure list may come from several sources: results from the same or similar equipment obtained during qualification and developmental tests, quality-control inspections, production environmental tests, and failure reports originating in the laboratory, field, or production facilities.

Specific failure data for the design feature will be summarized on the reliability study work sheet in the failure experience section.

Another prime source of input to the modes of failure is the training, experience, and skill of the originating engineer. His analysis of the design, the materials used, the production techniques and inspection processes, and the equipment's operating environments will permit him to predict modes of failure that might otherwise have to be determined during the testing cycle of our reliability improvement curve.

His predictions will serve at least two purposes: (1) They will highlight test procedures for proving the design or discovering the equipment's mode of failure, and (2) They will aid redesign and state-of-the-art advancement efforts by highlighting action items.

"The basic objective of missile system manufacturers is to produce a mature, reliable system in the shortest time and at the lowest possible cost."

Careful preparation of the reliability study work sheets will, in time, afford the user a compilation of data permitting more parts and components to be treated as standard building-block units and, consequently, further increase the slope of the reliability improvement curve for later projects.

The technique outlined can be summarized as a systematic approach to design, manufacturing, inspection, and process control analysis to highlight modes of equipment failure. Its logic is based on the need to isolate a mode of failure before a logical fix can be determined. It is only through isolation and fix that reliability can be improved.

At present, the primary technique used for isolating failures is testing. However, since we are all faced with tight schedules, we may become so involved in scheduling manpower to conduct a series of tests that we fail to plan the added effort necessary to reap full benefit from the test program—specifically the failure-investigation activity. This pitfall must be avoided.

Although I do not wish to minimize the importance of successful testing, I would like to emphasize the dependency of reliability improvement on failure analysis and, more specifically, on the determination of the mode of failure. The reliability study aids in the prevention of failures and speeds up the investigation of failures that occur. In addition, a good failure analysis will enable us to do a better reliability study in the future.

IF reliability studies are conducted concurrently with early design efforts—a program supporting our analogy to the stress analysis of a structural design—results may indicate the need for immediate modifications. It is far less costly, both in time and money, to modify a drawing than an expensive and intricate piece of equipment. Similarly, this reliability-study technique will prove useful in evaluating alternate design approaches to a problem.

The initiation of a reliability study during the determination of manufacturing procedures also may help eliminate manufacturing causes of unreliability. Again, rejection costs more than pay the cost of the study. Continued reliability studies of "in-use" manufacturing processes may further eliminate causes of unreliability.

Turning again to the test program, the results of reliability studies can be helpful to the test engineers while they plan their tests and, in case of failure, as they analyze the failed part to determine the mode of failure. Also, the study may aid the test engineers in setting up their tests to check for specific modes of failure.

As an example, the electrical stresses and operating temperature at which a specific electronic component functioned is of much greater value than the fact that the component did not fail during a given operating time.

At Martin-Denver, where initial application of the reliabilty study program was in the evaluation of the Titan's controls subsystem, more than a hundred specific action items already have resulted. Moreover, the study is not yet complete, since it is continuing through the important testing phase of the development program.

STILL, from the results obtained thus far, the indicated action items have resulted in improved inspection and manufacturing processes, improved electronic part application, better electronic part selection, and improved mechanical design.

In most cases, these improvements have been implemented without the added time and cost of running comparative tests. Since these results have been very satisfactory, we are extending the study effort to the other critical missile subsystems and components.

Therefore we can conclude that outputs from a reliability study serve as aids to the designer, the manufacturing engineer, quality-control engineers, test engineers, and that all-important individual, the company comptroller.

In addition, the procedures for reliability study analysis are most useful for training other engineers, and the organized data resulting from these studies are invaluable as they affect weapon system development time and state of the art.

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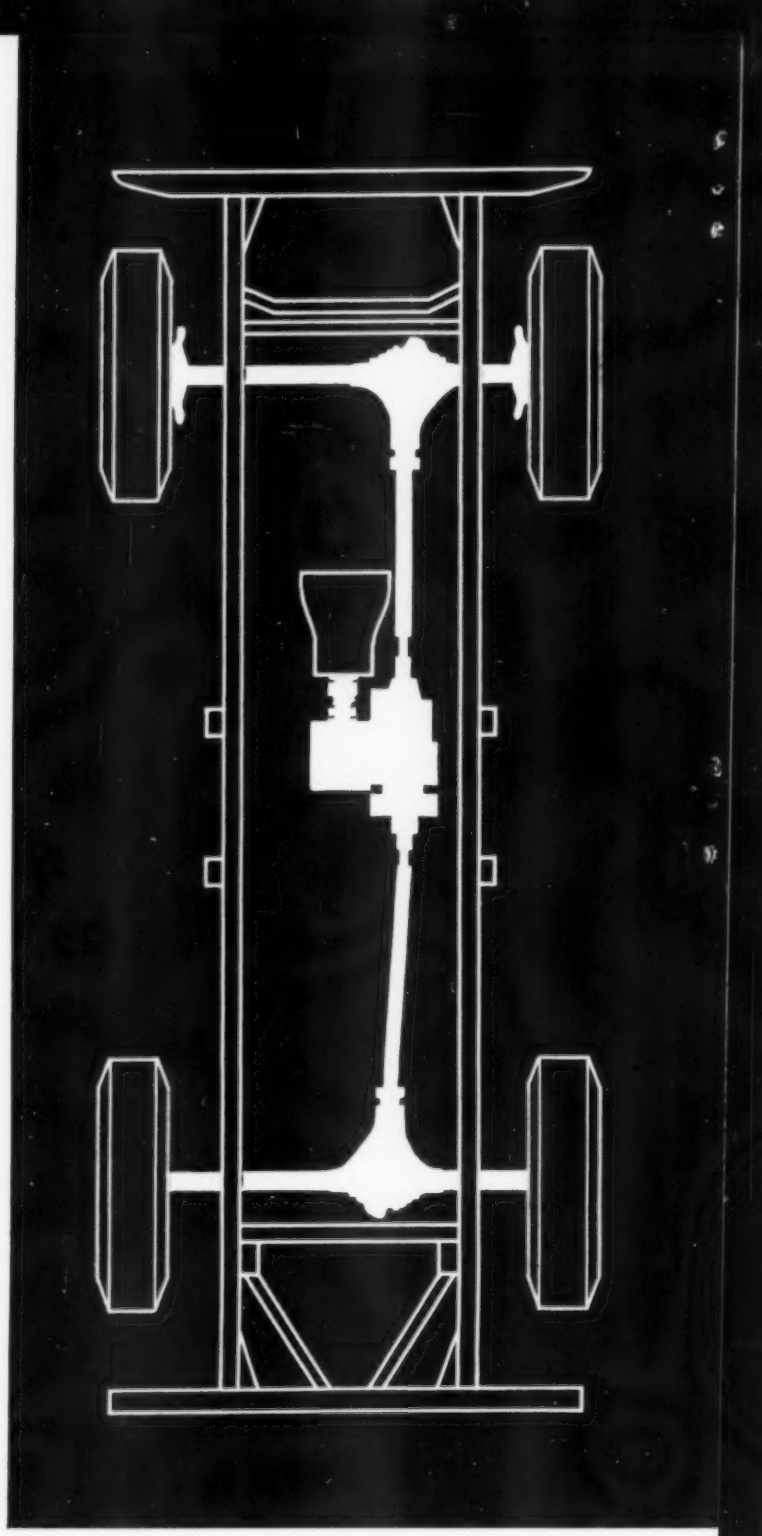

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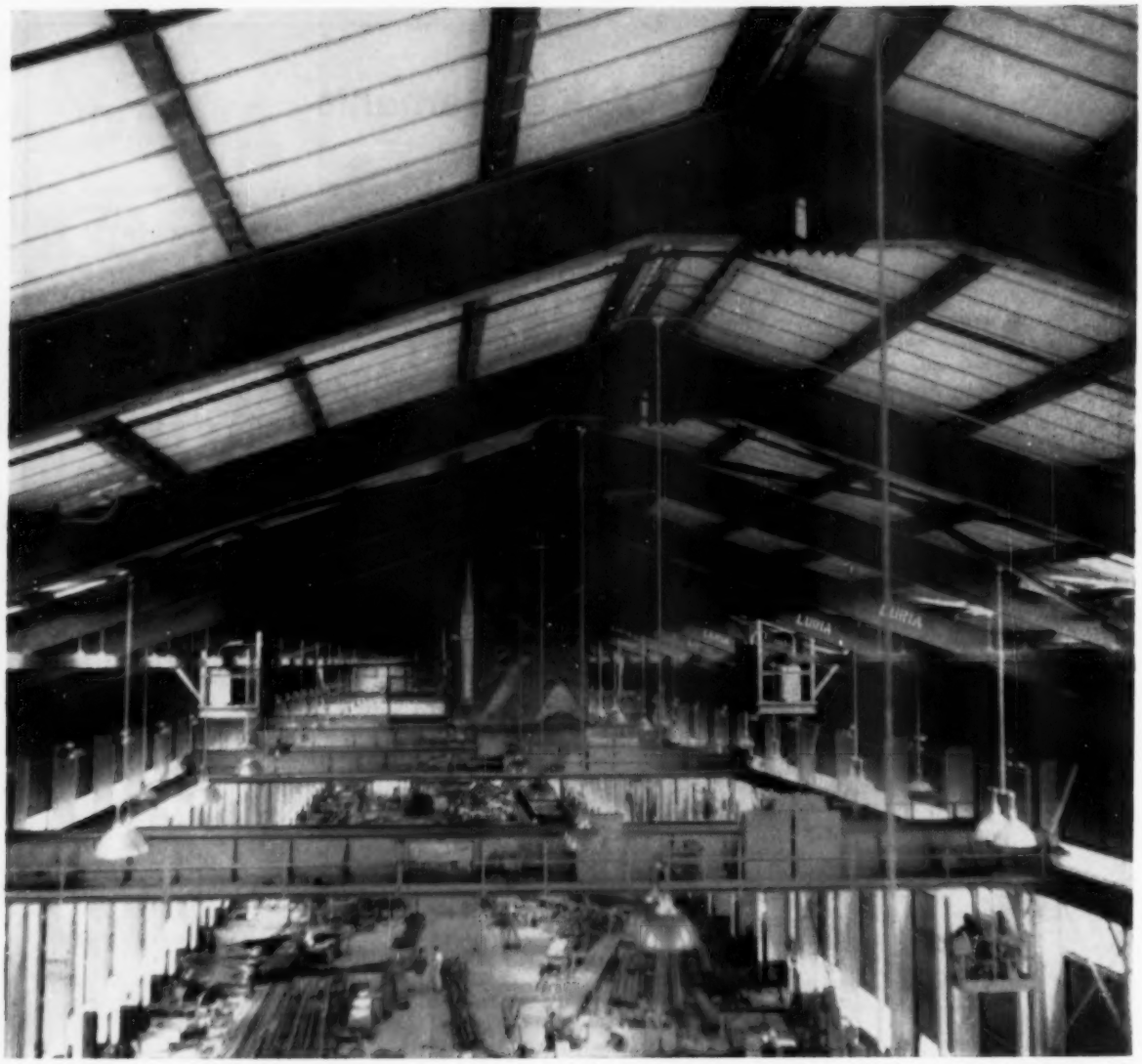

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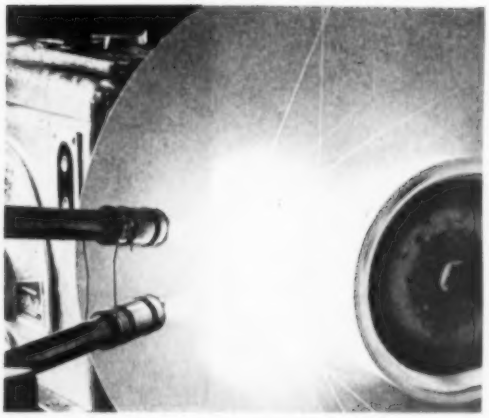

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